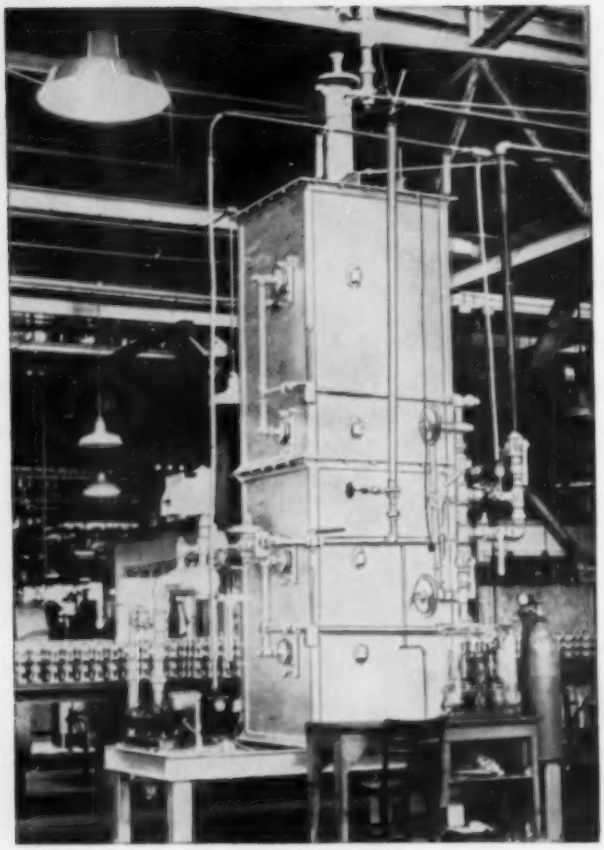
METAL PROGRESS

FEBRUARY 1955

going strong after 13 years



FIRST RX® GAS GENERATOR STILL PAYING OFF

This "pioneer" at Warner Gear Division, Borg-Warner Corp., Muncie, Ind., shows some of the advantages of 'Surface' endothermic gas generators. This was the first practical catalytic gas generator for continuous bright gas carburizing . . . and it's still in use. It has paid for itself many times since it started operating on April 4, 1941. As a result, Warner Gear has standardized on 'Surface' RX® gas generators for its gas carburizing operation; the world's largest single installation.

Surface Combustion has installed hundreds of RX® gas generators since 1941. They contribute to the making of every car made in the U. S. New developments have improved their accuracy, reliability and output. Users have found lower maintenance costs.

Find out what RX® atmosphere gas generators can do for *you*. Call for a sales engineer or write for Literature H54-6.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

Metal Progress

February . . 1955

Cover by Frank P. Saso – *Doors, windows, stairways and other building structures made of metal prompted this prize-winning design (honorable mention) in Metal Progress's annual competition at Cleveland School of Art.*

Ernest E. Thum, *Editor*
Marjorie R. Hyslop, *Managing Editor*
John Parina, Jr., *Associate Editor*

Engineering Articles

Carbon – a Neglected Metallurgical Tool?, by Carl E. Swartz 77

As a material of construction, carbon has long been neglected. Few metallurgists realize its possible applications in their work, and fewer still have had any experience with it. Nevertheless, in the foundry, in the steel mill, in nuclear reactor technology and in various other metallurgical operations, it has many properties which make it a useful and economical material.

Electrostatic Finishing of Appliances; a Pictorial Story 84

Mechanized lines for electrostatic spray-painting of laundry cabinets have increased production, improved quality and reduced cost of finishing at General Electric Co.'s Louisville, Ky., plant.

Germanium and Silicon for Electronic Devices, by Anthony S. Rugare 87

Crystals of precise and minute impurity for rugged miniature electronic devices are at present made more easily of germanium than of silicon, but silicon can operate at higher temperatures. Germanium is more efficient at high frequencies.

Salt Bath Hardening of Tools, by Elmer B. Hauser 96

A case history reporting that the salt bath method has increased output, quality and economy in the heat treatment of high speed toolsteels at Weldon Tool Co.

Heat Treatment of Titanium Alloys, by L. D. Jaffe 101

An examination of the large amount of published data leads to a systematic interpretation based on the known properties of the existing microconstituents and their changes during heat treatment.

"Plancor 422"–a Wartime Steel Plant, by M. E. Goetz 109

Troubles surmounted in design, construction and emergency operation of an integrated plant for making gun steel or aircraft quality steel from molten pig and own scrap, by duplexing openhearth and electric furnaces and rolling large ingots into forging blooms.

The Atomic Age

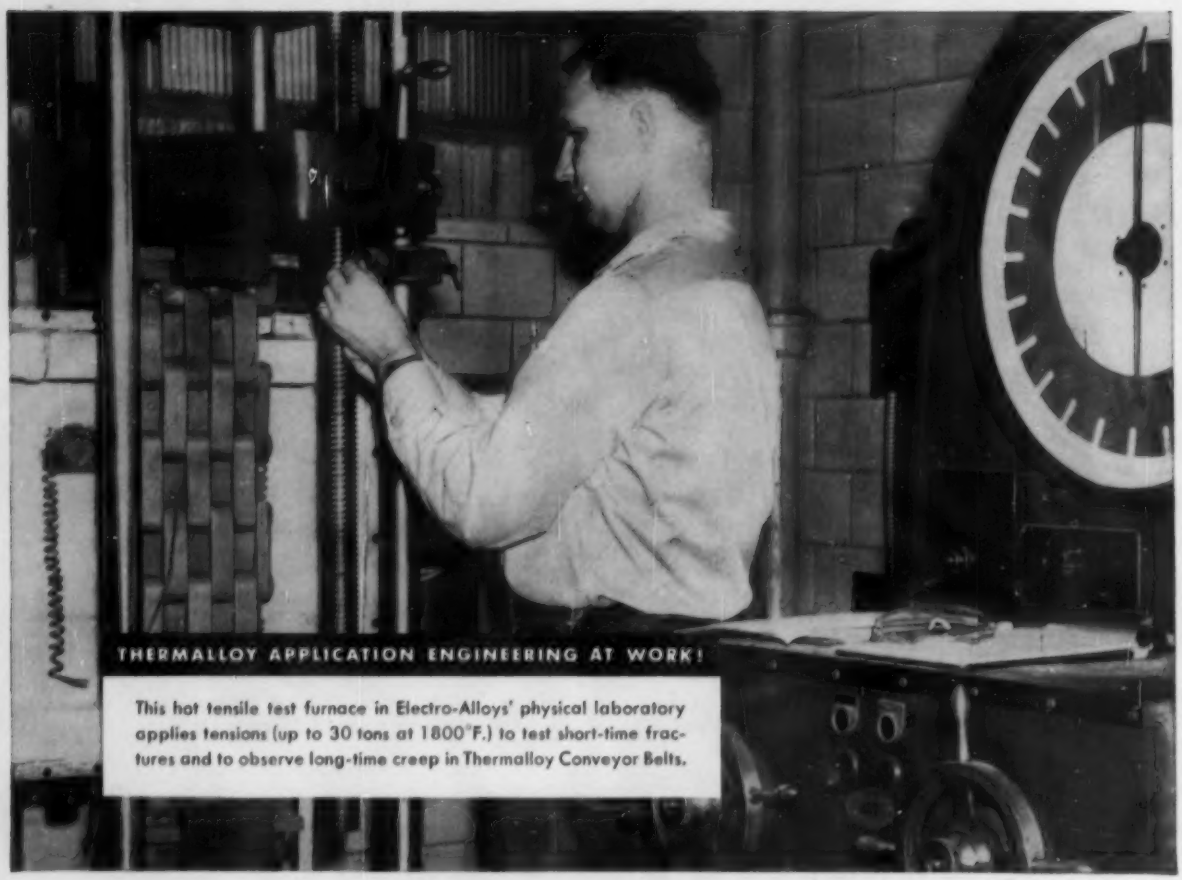
Atoms for Peace, Extracts from Statement by Henry Cabot Lodge 82

Brief survey of where we stand today in peaceful uses of the atom, and proposals for U. S. action during 1955 leading toward an international atomic agency. Supplemented by description of a typical research reactor by AEC Chairman Strauss.

Table of Contents Continued on Page 3

Published monthly except bi-weekly in July, by AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00. . . . The AMERICAN SOCIETY FOR METALS is not responsible for statements or opinions printed in this publication. . . . Requests for change in address should include *old* address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of date of issue. No claims allowed for overseas subscribers. Entered as second-class matter at the Post Office in Mt. Morris, Ill.

Copyright, 1955, by AMERICAN SOCIETY FOR METALS.

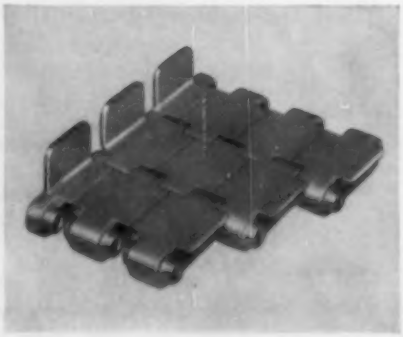

THERMALLOY APPLICATION ENGINEERING AT WORK!
This hot tensile test furnace in Electro-Alloys' physical laboratory applies tensions (up to 30 tons at 1800°F.) to test short-time fractures and to observe long-time creep in Thermalloy Conveyor Belts.

A miniature furnace to test theories!

Service life of a heat-treating furnace conveyor belt may be affected by so many variables, i.e. uneven loading, misalignment, temperature differentials, etc., that proper design, highest quality and the right material are of utmost importance.

At Electro-Alloys, a staff of engineers and metallurgists are constantly studying these factors in the physical testing laboratory shown above. A hot tensile test furnace is continually in use subjecting Thermalloy* conveyor belts to various combinations of loading and temperature. In this way, design theories developed by our engineers are tested and highest possible quality standards are maintained to insure production of furnace conveyor belts that will be the ultimate in trouble-free operation.

Electro-Alloys also applies engineering and metallurgical know-how in the production of heat-resistant Thermalloy castings for other furnace parts such as sprockets, idlers, skid rails or rollers, crossbeams, wall boxes and radiant tube assemblies. For complete information, call our nearest representative or write for Thermalloy Conveyor Belt Bulletin T-241, Electro-Alloys Division, 6002 Taylor St., Elyria, Ohio.



To meet extra-severe operating conditions, a Thermalloy Heavy-Duty Conveyor Belt was developed. This partially assembled belt shows the short integral cast pins that eliminate "crank-shafting."

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

*Reg. U. S. Pat. Off.

Eminent Living Metallurgist

Roy H. Davis, President, Atlas Steels Limited, by Harold J. Roast 92

Biographical appreciation of the Canadian engineering executive who is largely responsible for the phenomenal growth of this important toolsteel plant.

Book Review

Stainless Steel Classic, Reviewed by A. L. Feild 94

The latest edition of Monypenny's "Stainless Iron and Steel", first published in 1926, has been greatly expanded and issued in two volumes, which "are an essential part of the metallugrical library of the research metallurgist and scientist".

Light Metallurgy

Wonder Metals, by R. P. Lister 99

The author suspects that titanium must have some serious drawback, "now that there is enough of it for there to be anything wrong with". So it has always been with wonder metals – clear back to the bronze age.

Notebook

Dehomogenization of Solid Solutions, by L. Colombier 116

Spontaneous segregation of certain constituents of alloys in grain boundaries is advanced as a theory to explain phenomena of overheating and temper brittleness, as well as a number of other observations.

Data Sheet

Hardenability Bands for Standard H-Steels, 4032-H to 4150-H 108-B

Second of a series of eight sheets translating into simplified chart form the hardenability curves and data issued by the American Iron and Steel Institute.

Correspondence

A Job for A.S.M., by Joseph Warga 118

A standardized method for measurement of effective carburized case depth is needed, and might be most effective if sponsored by A.S.M.

Defines New Terms, by H. J. Beattie 118

Laves phase and chi phase are terms not yet found in dictionaries. The former is named for the German scientist who first recognized it.

Quench and Work Technique, by Richard F. Harvey 119

Source of the interrupted-quenching mechanical-working technique developed as an improvement over the basic martempering treatment.

Determining Sharpness Microscopically, by P. W. Goad 120

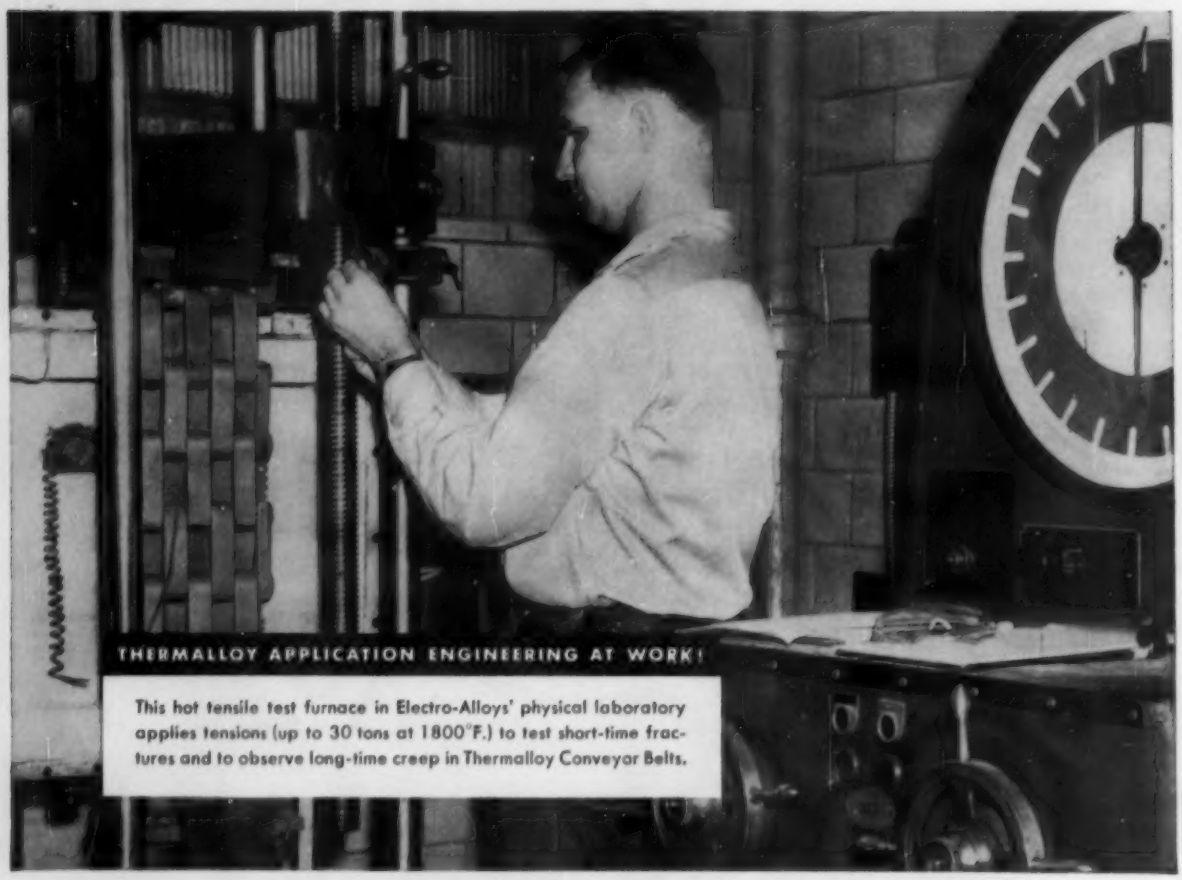
An Australian string-cutting sharpness test used to evaluate the sharpness of surgical instruments.

Digests of Important Articles

A Forgeable, High-Temperature Chromium-Iron Alloy 138
Flame Versus Induction Hardening 144
Causes and Prevention of Weld-Metal Cracking – Part I 146
Fatigue-Induced Micrographic Changes in Pure Aluminum 158
Spot Welding of Titanium 160
British Naval Gas Turbines 166
Useful Microscopic Techniques 168
Determining Amount of Nitrogen and Nitrides in Fe-C Alloys 172
Creep Tests of Smooth and Notched Specimens 180
Hydrogen in Iron-Carbon Alloys 188
Solidus and Liquidus of Highly Reactive Alloys 192
Thermal Conductivity of Refractory Materials 196
Two Mg-Zr Casting Alloys 202

Departments

As I Was Saying, by Bill Eisenman 5
Personals 122
Engineering Digests of New Products 13
Manufacturers' Literature 29
Advertisers' Index 212



THERMALLOY APPLICATION ENGINEERING AT WORK!

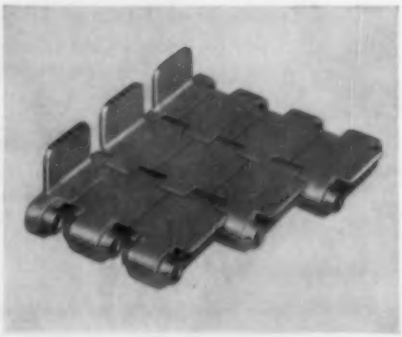
This hot tensile test furnace in Electro-Alloys' physical laboratory applies tensions (up to 30 tons at 1800°F.) to test short-time fractures and to observe long-time creep in Thermalloy Conveyor Belts.

A miniature furnace to test theories!

Service life of a heat-treating furnace conveyor belt may be affected by so many variables, i.e. uneven loading, misalignment, temperature differentials, etc., that proper design, highest quality and the right material are of utmost importance.

At Electro-Alloys, a staff of engineers and metallurgists are constantly studying these factors in the physical testing laboratory shown above. A hot tensile test furnace is continually in use subjecting Thermalloy* conveyor belts to various combinations of loading and temperature. In this way, design theories developed by our engineers are tested and highest possible quality standards are maintained to insure production of furnace conveyor belts that will be the ultimate in trouble-free operation.

Electro-Alloys also applies engineering and metallurgical know-how in the production of heat-resistant Thermalloy castings for other furnace parts such as sprockets, idlers, skid rails or rollers, crossbeams, wall boxes and radiant tube assemblies. For complete information, call our nearest representative or write for Thermalloy Conveyor Belt Bulletin T-241, Electro-Alloys Division, 6002 Taylor St., Elyria, Ohio.



To meet extra-severe operating conditions, a Thermalloy Heavy-Duty Conveyor Belt was developed. This partially assembled belt shows the short integral cast pins that eliminate "crank-shafting."

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

Elyria, Ohio

*Reg. U. S. Pat. Off.

Eminent Living Metallurgist

Roy H. Davis, President, Atlas Steels Limited, by Harold J. Roast 92

Biographical appreciation of the Canadian engineering executive who is largely responsible for the phenomenal growth of this important toolsteel plant.

Book Review

Stainless Steel Classic, Reviewed by A. L. Feild 94

The latest edition of Monypenny's "Stainless Iron and Steel", first published in 1926, has been greatly expanded and issued in two volumes, which "are an essential part of the metallugrical library of the research metallurgist and scientist".

Light Metallurgy

Wonder Metals, by R. P. Lister 99

The author suspects that titanium must have some serious drawback, "now that there is enough of it for there to be anything wrong with". So it has always been with wonder metals – clear back to the bronze age.

Notebook

Dehomogenization of Solid Solutions, by L. Colombier 116

Spontaneous segregation of certain constituents of alloys in grain boundaries is advanced as a theory to explain phenomena of overheating and temper brittleness, as well as a number of other observations.

Data Sheet

Hardenability Bands for Standard H-Steels, 4032-H to 4150-H 108-B

Second of a series of eight sheets translating into simplified chart form the hardenability curves and data issued by the American Iron and Steel Institute.

Correspondence

A Job for A.S.M., by Joseph Warga 118

A standardized method for measurement of effective carburized case depth is needed, and might be most effective if sponsored by A.S.M.

Defines New Terms, by H. J. Beattie 118

Laves phase and chi phase are terms not yet found in dictionaries. The former is named for the German scientist who first recognized it.

Quench and Work Technique, by Richard F. Harvey 119

Source of the interrupted-quenching mechanical-working technique developed as an improvement over the basic martempering treatment.

Determining Sharpness Microscopically, by P. W. Goad 120

An Australian string-cutting sharpness test used to evaluate the sharpness of surgical instruments.

Digests of Important Articles

A Forgeable, High-Temperature Chromium-Iron Alloy 138
Flame Versus Induction Hardening 144
Causes and Prevention of Weld-Metal Cracking – Part I 146
Fatigue-Induced Micrographic Changes in Pure Aluminum 158
Spot Welding of Titanium 160
British Naval Gas Turbines 166
Useful Microscopic Techniques 168
Determining Amount of Nitrogen and Nitrides in Fe-C Alloys 172
Creep Tests of Smooth and Notched Specimens 180
Hydrogen in Iron-Carbon Alloys 188
Solidus and Liquidus of Highly Reactive Alloys 192
Thermal Conductivity of Refractory Materials 196
Two Mg-Zr Casting Alloys 202

Departments

As I Was Saying, by Bill Eisenman 5
Personals 122
Engineering Digests of New Products 13
Manufacturers' Literature 29
Advertisers' Index 212

These full-length dome cars are part of an order for 121 being built by The Budd Company for the Santa Fe Railway. They feature not only unexcelled facilities for passenger enjoyment . . . but also the *safety and economy* of Crucible Rezistal® stainless steel.

Because they're *all stainless* — their strength-weight ratio is higher than you'd find in low alloy carbon steel. The cars are *lighter yet stronger* than ordinary steel cars, which means the Santa Fe will be able to haul as many as 25 of these cars with the same drawbar pull they'd need for 20 low alloy carbon steel cars.

What's more, the passive surface of Crucible stainless will never need painting . . . never need more than a "once-over-lightly" by maintenance crews to keep its sparkling new look. And, beneath the skin, where corrosion and vibration can undermine the strength of vital structural members — the high corrosion resistance and fatigue strength of Crucible stainless will keep these cars in service for a lifetime.

Budd would not have chosen stainless for all the cars they build unless it was a *practical shop metal.* And it is. For it can be formed, machined, welded, drawn, heat-treated — processed in any way you'd normally use for ordinary steel.

So don't forget the Crucible family of stainless steels where you need corrosion resistance . . . high fatigue, creep and structural strength . . . resistance to wear and temperature extremes . . . workability. We'll be glad to help you select the best stainless grade for your job. Let our Metallurgical Engineering Department make practical suggestions.

CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking **STAINLESS STEELS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

As I was saying...

IT WAS about 30 years ago that an enthusiastic delegation of California members cornered the Board of Trustees of the ASM at a meeting during the Detroit convention and gave the startling information that in their combined opinion the West Coast was ready for and should have a Metal Show.

President Fred Hughes and the other Board members glanced in my direction with lifted eyebrows as much as to say, "What the heck, Bill, did you arrange for this squad call so you could be sent to your old stamping grounds on an investigating trip?" But I kept a straight face (as straight as possible) and turned over in my mind how fine it would be to go to the Coast (a long way in "them there" days), visit my P.G. campus, Stanford, and take a look at what really had happened on the Coast since my return to the East.

So out to the Coast went Mill and Bill to receive such a welcome on the Santa Fe platform as we never experienced before. The chapter officers, the wives, the officials of the Chamber of Commerce, the publicity department and photographers made us feel very important and almost convinced me then and there that there sure should be a Metal Show on the West Coast. Maurice Chevalier and his wife and a pet turtle came through on the Chief with Mill and me and they also were met at the station by photographers with six starlets in Bikini suits and a straw hat for Chevalier, but the delegation meeting the ASM representatives far outnumbered the movie crowd and were much more warmly dressed.

And that was the beginning of the Western Metal Congress and Western Metal Exposition; the first was held in Los Angeles in 1929, and the ninth now scheduled for next month, March 28 through April 1, 1955. These events have grown not only in size and coverage but in the high esteem and prestige of the growing metal industry of the West.

The Congress will really be a congress since the western divisions of 24 national technical societies are cooperating and co-sponsoring this great educational program. The American Welding Society, the Society for Nondestructive Testing, the Industrial Heating Equipment Association and the ASM have each arranged complete technical programs for the Congress, all sessions and papers being slanted to the industrial interests of the West.

The Exposition is a sell-out – the largest ever held in the West. It will be the Show of Shows – all of which proves the wisdom and foresight of that squad of western sharp-shooter salesmen who blasted their way to the heart of the subject and catapulted the ASM to pioneering the metal engineering activities in the Golden West.

See you in L.A.

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

Solventol research has recently developed a new Series of Di-Phase Metal Cleaners which give more protection in both dip and spray cleaning operations. These improved cleaning materials now have a new high flash point minimum of 210°F. plus, making possible the following important advantages:

1. Much safer operation.
2. Less solvent loss.
3. Greater savings.
4. Improved cleaning efficiency.
5. Improved temporary rust protection.

SOLVENTOL
DI-PHASE
METAL CLEANING

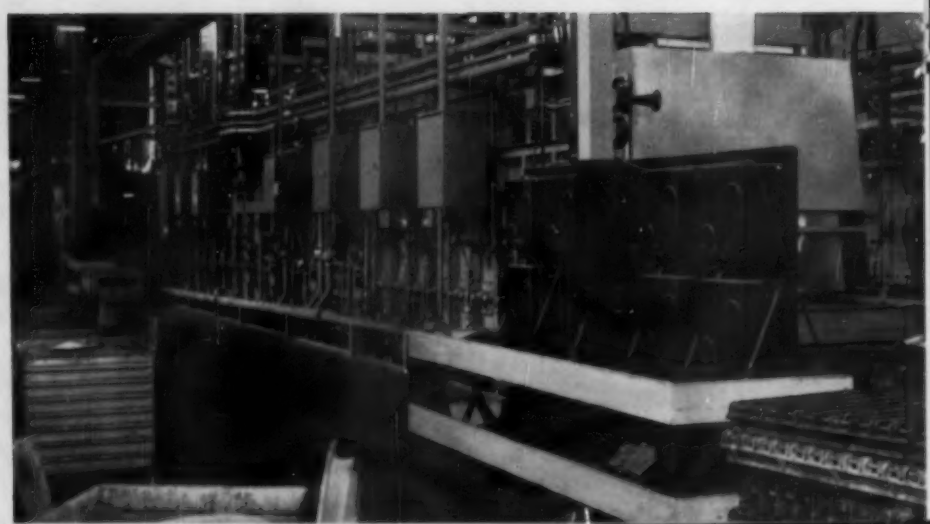
SEND TODAY for technical specifications and descriptive literature on the NEW Solventol Di-Phase Liquid Series of Metal Cleaning Compounds.

SOLVENTOL CHEMICAL PRODUCTS, INC.
DETROIT 3, MICH. PH. TOWNSEND 8-8466

NAME_____
POSITION_____
ADDRESS_____
CITY_____ STATE_____

Caterpillar bulldozers speeded construction on the Banff Windermere Highway at Mount Eisenhower in Alberta, Canada.

One of six at Caterpillar, this Westinghouse cycle annealer treats metals in a controlled atmosphere to avoid scaling.



Westinghouse annealers at Caterpillar® improve machinability

To insure quality products at competitive prices, Caterpillar Tractor Company is quick to study and test any new idea that might lead to reduced production costs and improved product performance. For instance, isothermal annealing of forgings before machining promised such results.

Installation of two Westinghouse cycle annealing furnaces demonstrated their value. Now Caterpillar uses six Westinghouse furnaces—some electric, some gas fired. Westinghouse tailored them to fit Caterpillar's precise needs.

These furnaces have proved they can produce the kind of microstructure allowing the highest rate of machinability and the desired finish. Here's another example of how Westinghouse engineers, working closely with the customer, help turn out a finer product at less cost. A call to your nearby Westinghouse Sales Engineer, The Man With The Facts, may produce heat-treating ideas for you, too. J-10436

YOU CAN BE SURE...IF IT'S Westinghouse

WESTINGHOUSE 4-POINT SERVICE produces effective heat-treating

1 Engineering consultation
2 Equipment design
3 Quality manufacturing
4 Packaged installation

Westinghouse Electric Corporation
3 Gateway Center, P. O. Box 868
Pittsburgh 30, Pa.

Please send me a free copy of the 40-page book, *Westinghouse Furnaces, Gas or Electric* (B-5459).

Name_____

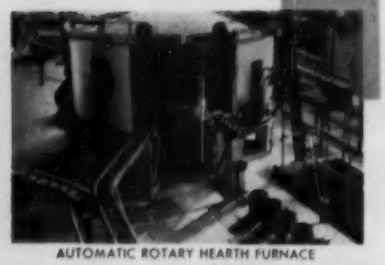
Title_____

Company_____

Address_____

City_____ State_____

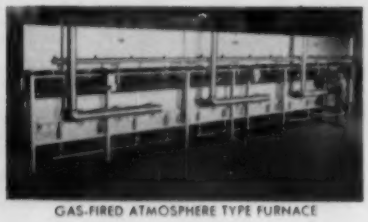
FIELD



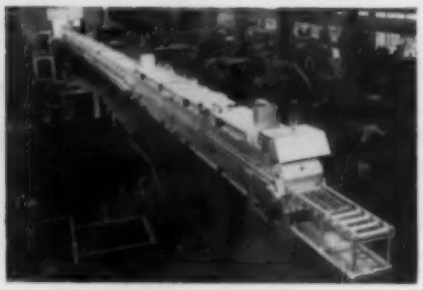
AUTOMATIC ROTARY HEARTH FURNACE

ROLLER HEARTH FURNACE

CONTINUOUS MESH BELT RECIRCULATING FURNACE

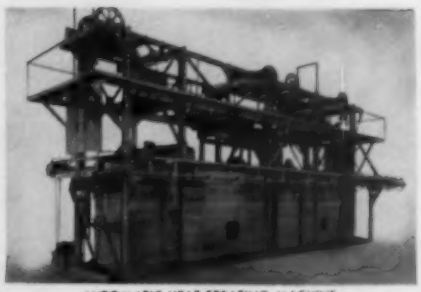


GAS-FIRED ATMOSPHERE TYPE FURNACE



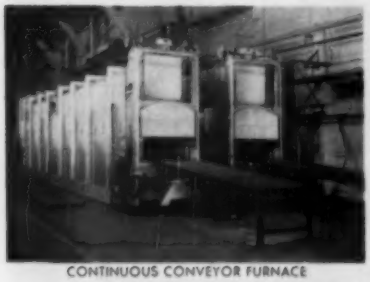
CONTINUOUS ELECTRIC FURNACE

ALUMINUM BILLET HEATER



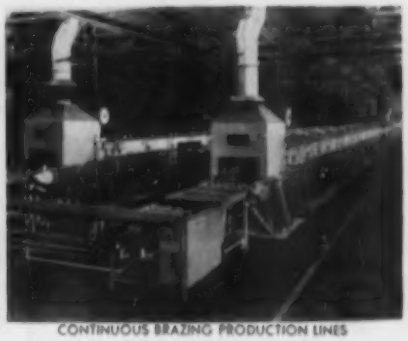
AUTOMATIC HEAT TREATING MACHINE

ERECTED



CONTINUOUS CONVEYOR FURNACE

AUTOMATIC ROLLER GRID FURNACE



CONTINUOUS BRAZING PRODUCTION LINES

CONTINUOUS VITREOUS ENAMELING LINE

CONTINUOUS CARBO-NITRIDING FURNACE

BIG ONES...by Lindberg

Maybe you haven't heard the news. Lindberg is now set up to field-erect any type of industrial heating or processing installation. Pictured on these pages are just a few of the large field-erected installations already put up by Lindberg. More are being built right now.

You get a complete package deal from Lindberg. Expert engineers consult with you and analyze your needs. Then they plan and design an installation to meet your specific requirements, whether you need a single furnace or a complete production line. And Lindberg will build it for you, right in your own plant.

To get on-the-spot service from an expert Lindberg engineer, just call your nearest Lindberg Field Office (you'll find the number in the classified section of your phone book, or in the Trade Directories).

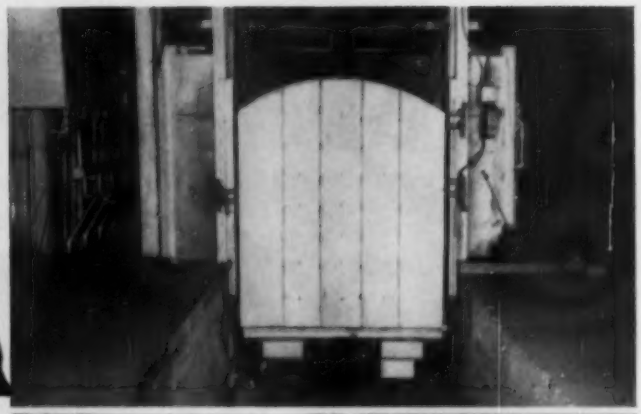
LINDBERG INDUSTRIAL

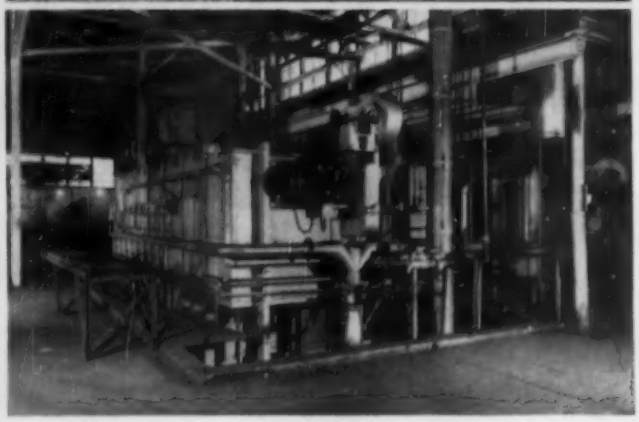
LINDBERG INDUSTRIAL CORPORATION

Chicago Plant: 2321 West Hubbard Street, Chicago, Illinois

Field Offices in principal cities. **Los Angeles Plant:** 11937 Regentview Avenue, at Downey, California • **Associate Companies:** Lindberg Engineering Company, Chicago • EPCO-Lindberg, Ltd., Montreal • Lindberg Italiana, Milan, Italy

2000°F TEMPERATURE RANGE HEAT-TREAT FURNACE





engineered and installed by carl mayer

Here is another of the many outstanding heat-treat furnace installations blueprinted by the Carl Mayer Corporation to fit a given requirement.

This recirculating, gas-fired, car bottom type, heat-treat furnace at the Golden Foundry Co., Columbus, Indiana was engineered to meet a high temperature range requirement of 2000°F for the production of cast iron engine blocks. Like so many other Carl Mayer installations, it has proven an efficient, economical asset to Golden Foundry's production operation.

Write for our bulletin No. HT-53, or ask for a representative to call. Our engineers will be happy to consult with you on *your* particular problem.

Over 30 years' experience in the engineering, designing and installation of industrial ovens and furnaces for both large and small industries everywhere.

Recipient "Trinks" Industrial Heating Award for Outstanding Achievement

THE carl mayer CORP.

3030 EUCLID AVENUE CLEVELAND 15, OHIO

OTHER PRODUCTS: Core Ovens • Mold Ovens • Rod Bakers • Welding Rod Ovens • Paint and Ceramic Drying Ovens • Special Processing Equipment and Accessories

QUENCHING... the tail that wags the dog

Steel analysis can be perfect, temperatures "right on the nose", atmospheres ideal—but it's the *quench*—the tail end of the heat treating process that makes the rest of the operation pay off.

And when that quench is oil, don't take chances—use Houghto-Quench.

- It provides complete "wet-out"—no soft spots, less carry-off.
- It provides maximum stability—doesn't "thicken-up", rarely has to be changed.
- It gives you the speed you need—other oils can't touch the quenching speed of Houghto-Quench, and it's this speed that assures adequate hardness even for steels in the low hardenability range and heavy sections.

It doesn't pay to take chances with ordinary, inferior quenching oils! Ask your Houghton Man to show you the superior performance of Houghto-Quench. Or, write for "Quenching" folder. E. F. Houghton & Co., 303 West Lehigh Avenue, Phila. 33, Pa.

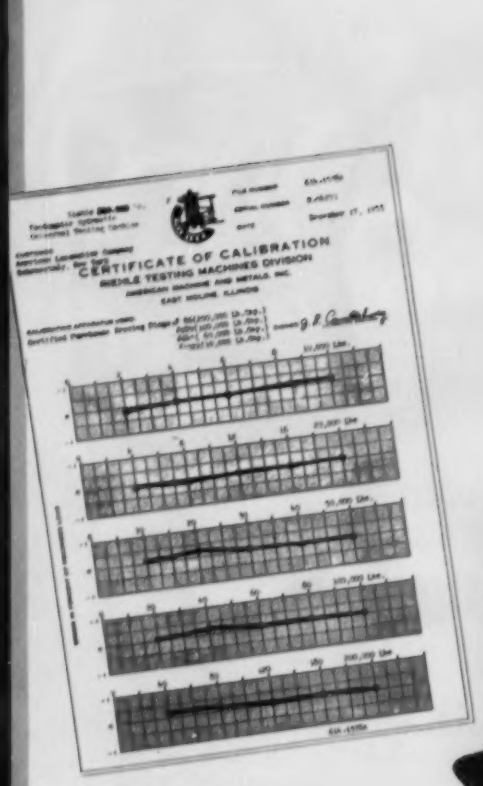
QUENCHING OILS

... products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .



What's the Date of Your Last Calibration?

If it's been some time since your testing equipment was calibrated, can you be sure that your test results are accurate?

You can eliminate all doubt by utilizing Riehle's calibration service regularly. It's designed to keep all types and all makes of testing equipment in top operating condition . . . and to prevent costly breakdowns. Performed by Riehle engineers, this service is truly *complete*. It not only covers calibration, but also includes minor adjustments when necessary.

Your machines are accurately calibrated with proving rings which are checked and calibrated annually by the U. S. Bureau of Standards. Upon completion of calibration, you receive a certificate which attests to the accuracy of the machine, showing exact percentage of error on every scale range.

Riehle calibration engineers are spotted throughout the country to give the quickest possible service. Their schedules for the weeks ahead are being made up now. Why not arrange to have a Riehle engineer inspect and service your testing equipment regularly? Just mail coupon for further details, without obligation.

RIEHLE

TESTING MACHINES

Division of American Machine and Metals, Inc.

East Moline, Illinois

"One test is worth a thousand expert opinions"

MAIL COUPON TODAY!

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-255, East Moline, Illinois

☐ Without obligation, send me further details on Riehle's calibration service.

☐ Send me new free bulletin on Riehle's full line of testing machinery and equipment.

FIRM NAME _____

ADDRESS _____

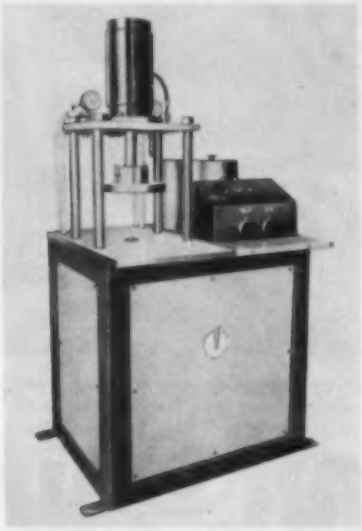
CITY _____ ZONE _____ STATE _____

ATTENTION MR. _____

engineering digest OF NEW PRODUCTS

Investment Casting

A completely automatic injection press designed for large volume production of wax or plastic patterns for industrial investment casting has been announced by the Centrifugal Casting Supply Co. Among its features is the



die clamping device, which is automatically motivated by a high pressure air cylinder. Pressure gages indicate precise pressure at all times. The platen pressure pad jointed to the cylinder drive rod, allows up to 15° tilt in any direction. Springs in the pressure pad absorb impact and allow air to escape during injection. The tank holds 75 lb. of injection material at temperatures of 120 to 250° F. The hardened steel injection nozzle is heated during operation to maintain temperature of material during injection. Injection pressures up to 1500 psi. are possible.

For further information circle No. 309 on literature request card on p. 36-B.

Silver Brazing Alloys

The Air Reduction Sales Co. has announced a new line of silver brazing alloys and flux. These alloys are available in rod, wire, sheet, rings and gaskets, as well as special shapes. Alloys of special composition to fit any production requirement are also available. The flux is in paste form and will not freeze, crystallize nor separate and the residue rinses off in hot water. Bonds are liquid and gas tight under heavy pressures and they are able to withstand shock, vibration and temperature changes. High thermal and electrical conductivity plus high corrosion resistance are other advantages. It joins practically all ferrous, nonferrous and dissimilar metals and alloys that have melting points above its free-flowing temperatures.

For further information circle No. 310 on literature request card on p. 36-B.

Electrolytic Manganese

Production of electrolytic manganese at its new plant at Marietta, Ohio, has been announced by Electro Metallurgical Co. The plant will have a capacity of about 6000 tons a year when all the electrolytic units are in full operation. The process being used produces minimum 99.9% pure manganese metal in plate form about ⅛ in. thick. The metal is suitable for all uses where high purity manganese is required, such as stainless steels, high-temperature alloys and the nonferrous alloys containing manganese.

For further information circle No. 311 on literature request card on p. 36-B.

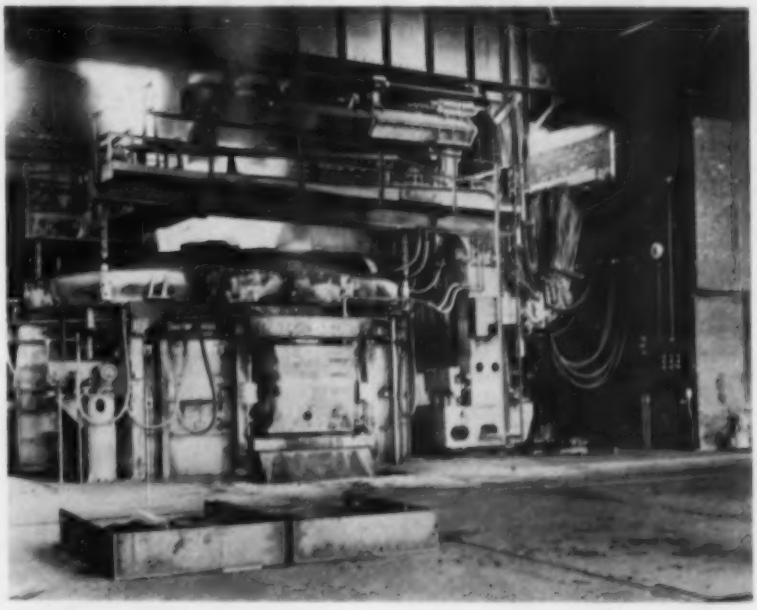
Annealing Titanium

High Vacuum Equipment Corp. has found that high vacuum annealing of titanium parts removed hydrogen and

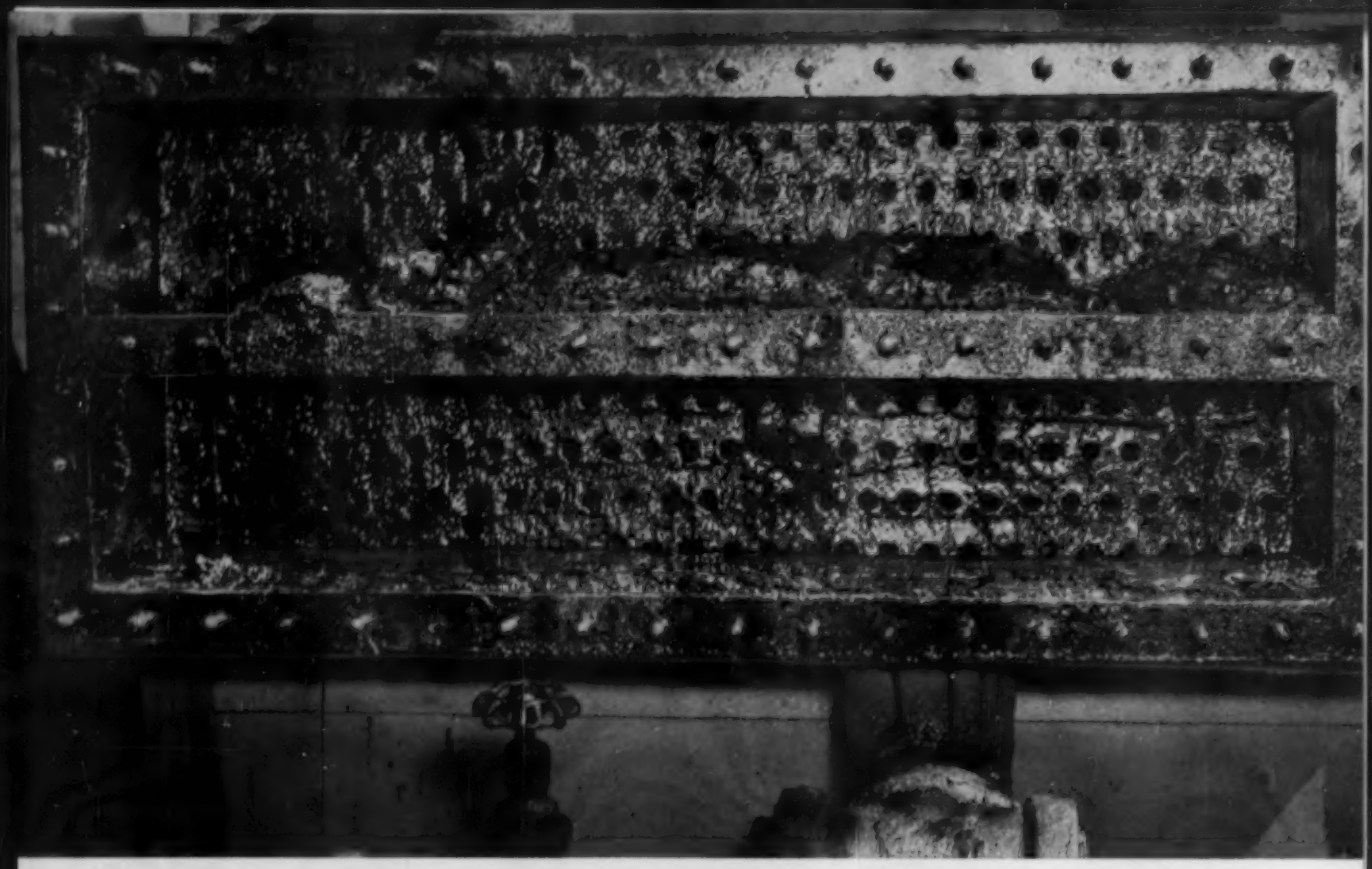
Furnace Accessories

The largest electric furnaces built to date have just been completed by American Bridge and are going into service at McLouth Steel Corp. These 200-ton Heroult furnaces, with inside shell diameter of 24½ ft., handle carbon steel heats weighing an average of 180 tons. Combined weight of furnace and heat is 700 tons. To tilt this heavy load, a double reduction, Cone-Drive double enveloping speed reducer is used. Capacity of reducer and the smoothness of operation both have an important bearing on the overall continued operation of the furnaces. Three 5 and 12 in. center distance double-reduction units are used to raise and lower a large mass consisting of the mast stems, mast arms, electrode holders, electrodes, bus tubes and secondary cables over a speed range varying from 0 to about 7½ fpm. The drive mechanisms consist of an electric motor driving a Cone-Drive reducer with a drum on the output shaft on which the lifting cable is wrapped. Lifting doors also use the same reducers.

For further information circle No. 312 on literature request card on p. 36-B.



ATTENTION MR.



If you use an ordinary quenching oil that forms sludge deposits, here's what can happen to your oil cooler.

SUN QUENCHING OIL LIGHT WON'T CLOG COOLERS

Sludge lowers operating efficiency, ups maintenance costs, cuts output. Sun Quenching Oil Light, when used at normal temperatures, keeps coolers clean, because it has a natural detergent action that prevents the formation of sludge deposits and aids in removing any deposits that have accumulated. And this oil thins out when heated—reduces drag-out, brings operating costs down. The booklet "Sun Quenching Oils" tells the story of Sun's money-saving quenching oils. Call a Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP2.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

SUNOCO®

PHILADELPHIA 3, PA. • SUN OIL COMPANY LTD., TORONTO & MONTREAL

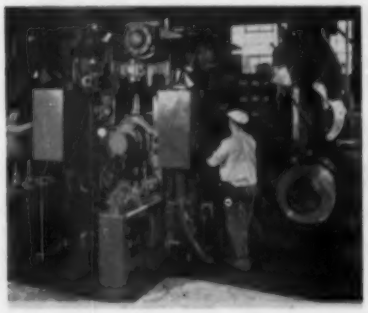
thereby greatly increased the strength and life of the parts. Hydrogen is present to some degree in all titanium and by removing it and other unwanted gases during the annealing cycle, parts are made more ductile, have greater fatigue resistance, longer

life and they can be made more light weight. High vacuum annealing furnaces handle big sheets, castings and long rods. Horizontal or vertical designs are available to handle from several pounds to several tons, while operating at pressures of less than a micron and temperatures up to 2000° F.

For further information circle No. 313 on literature request card on p. 36-B.

Rolling Mill

A new combination 2-high, 4-high reversing mill has been announced by Lewis Machinery Div. It can both cold reduce and skin pass either light or heavy gage material. When used as a



4-high mill, it has driven back-up rolls with each roll having its own individual motor without mechanical tie-in. When used as a 2-high mill the same motors and drive are utilized. It will operate at from 600 to 1800 ft. per min.

For further information circle No. 314 on literature request card on p. 36-B.

Limit Controller

Wheelco Instrument Div. has announced an electronic limit controller for the 400-series Capacitrol. It will automatically shut off the fuel supply at any specified temperature manually set on the indicating scale and, if so desired, will sound an alarm. A two compartment, die cast case, with either surface or flush mounting, houses the instrument components.

For further information circle No. 315 on literature request card on p. 36-B.

Coatings

Vitreco, Inc., has announced a new line of inorganic silicate coatings for fusing to ferrous metals at temperatures from 900 to 1200° F. Porcenells are available that are primarily adapted to architectural and decorative uses as well as those designed primarily for corrosion protection. As the former are used primarily by enamel shops, they are for the most part supplied as frits. These frits are milled with water, color oxides and standard mill additions to form the paint-like slurry that is applied to the ware. The Porcenells that are designed primarily for corrosion protection are available as premilled compounds which need only be mixed with water and color oxide to form the slurry. The pieces to be coated must be clean. They are then dipped in or sprayed with the slurry of Porcenell by any one of a number of conventional methods. The water that had been mixed with the Porcenell is evaporated, using

Now

for economical mechanical low temperature refrigeration

SUB-ZERO A-120-1

- **Costs less than $1500.00**
- **1 cubic foot capacity**
- **Simple "plug-in" unit**

Here's the new Cincinnati Sub-Zero chilling machine engineered to the needs of heat treating laboratories, experimental departments, developmental centers and similar "limited production" users. The Model A-120-1 has the capacity to chill 25 pounds of steel an hour from +80° to —120° F. It is easy to start—just plug it into a wall socket—it costs only pennies a day to operate. Hermetically sealed refrigeration; all-steel construction. Instrumentation as required. Observation window, entrance holes, heaters and other test equipment available as accessories. Other units available in sizes to meet your needs.

Write for full information

Cincinnati Sub-Zero Products

3930-S5 Reading Rd. Cincinnati 29, Ohio

GASMACO'S

TOOL ROOM FURNACE

Features

TEMPERATURES

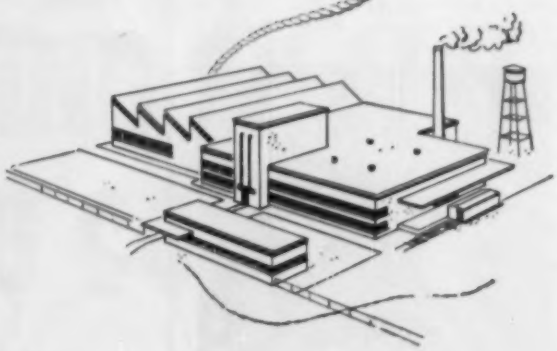
TO 2500° F.

WITH ATMOSPHERE

Lassoing Profits For Industry —

The GASMACO Tool Room Furnace employs Patented Refractory Radiant Tubes permitting furnace temperatures to 2500° F. . . . with controlled atmosphere, cylinder operated door mechanism, silicon carbide hearth, flue gas eductors, accurate temperature control — gas fired.

Other GASMACO EQUIPMENT: Direct, Radiant Tube, or Convection Heated Furnaces . . . Rotary or Pusher Type . . . High Temperature Roller Hearth . . . Pit Type . . . Bar Reheating . . . Slab Heaters . . . Cooling Tables and Conveyors, Charging Equipment and Manipulators.



REPRESENTATIVES IN:

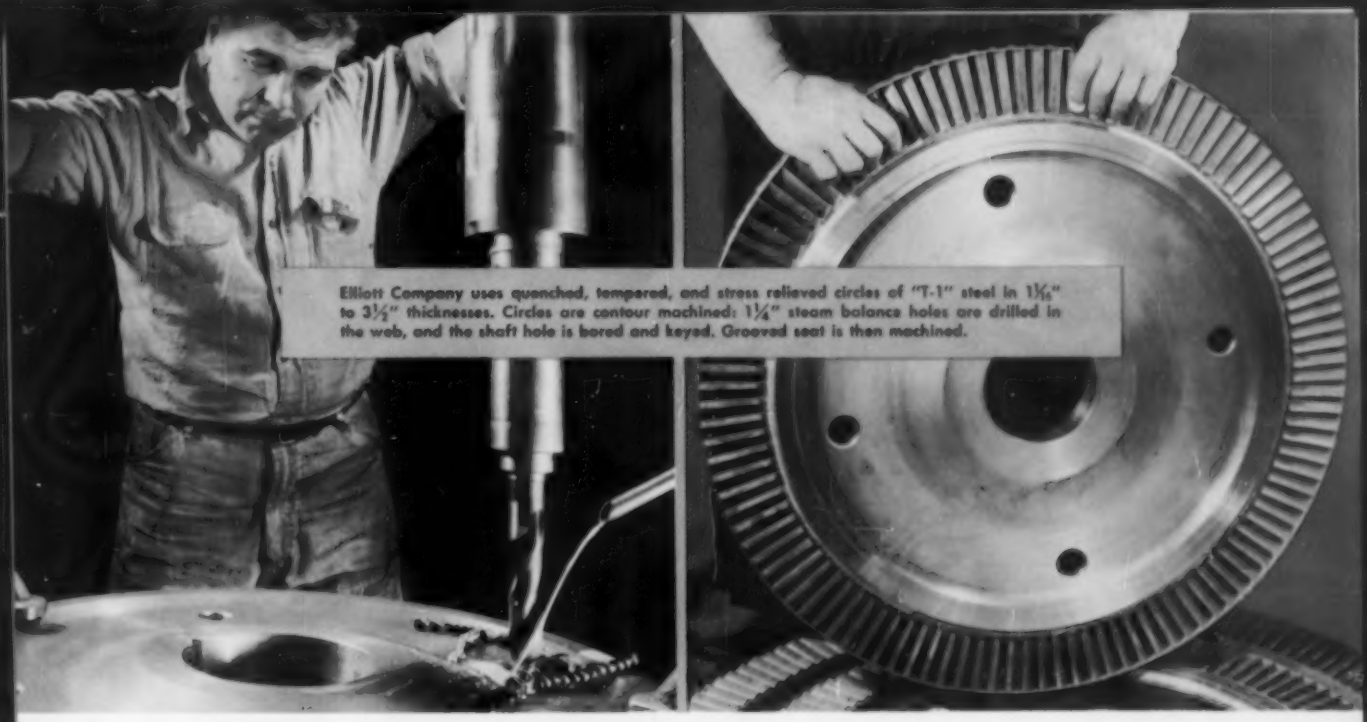
BIRMINGHAM • BOSTON • CHICAGO • ST. LOUIS • LOS ANGELES • SAN FRANCISCO

THE GAS MACHINERY COMPANY

16106 WATERLOO ROAD
CLEVELAND 10, OHIO

Designers • Fabricators • Erectors
Gas Plant Equipment and
Industrial Furnaces

THE GAS MACHINERY CO. (Canada), Ltd.
HAMILTON, ONTARIO



Elliott Company uses quenched, tempered, and stress relieved circles of "T-1" steel in 1 5/16" to 3½" thicknesses. Circles are contour machined; 1¼" steam balance holes are drilled in the web, and the shaft hole is bored and keyed. Grooved seat is then machined.

New USS "T" Steel cuts material cost 60% in rotor discs of small turbines

Provides high strength at high temperature, and stability at high speed of rotation

• The Elliott Company, Jeannette, Pennsylvania, makes industrial steam turbines for driving pumps, fans, blowers, and other rotating equipment. The steel for the turbine discs must withstand high stresses at high temperatures and at speeds as high as 6,000 rpm. It must be sound throughout. That's why Elliott Company has switched to new USS "T-1" Steel in these discs.

"T-1" provides a minimum yield strength of 90,000 psi. and good creep rupture strength to 900°F. It poses no severe fabrication problems. What's more, "T-1" costs 60% less in this turbine application than the alloy steel previously used. And the switch to "T-1" required no change in design.

Although USS "T-1" Steel is comparatively new, it already has proved well suited to a great variety of applications. In addition to great high-temperature strength, it has extraordinary toughness at temperatures far below zero. It has excellent resistance to impact abuse, impact abrasion, and atmospheric corrosion. By taking advantage of these superior properties, you can reduce the size and weight, increase the strength and durability, and reduce the cost of such varied equipment as pressure vessels, power shovels, draft lines, storage tanks, conveyors, bridges, and towers. Where field fabrication or repairs are necessary or desirable, "T-1" cuts costs still further because it can be welded or flame cut either in shop or field without pre-heating or stress relieving.

Send the coupon for complete information.

United States Steel, Room 4606
525 William Penn Place
Pittsburgh 30, Pa.

☐ Please send me your booklet, "United States Steel presents T-1" which contains the full story of "T-1" steel.

☐ Have your representative get in touch with me.

Name.....

Address.....

City.....State.....

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T" CONSTRUCTIONAL ALLOY STEEL

USS

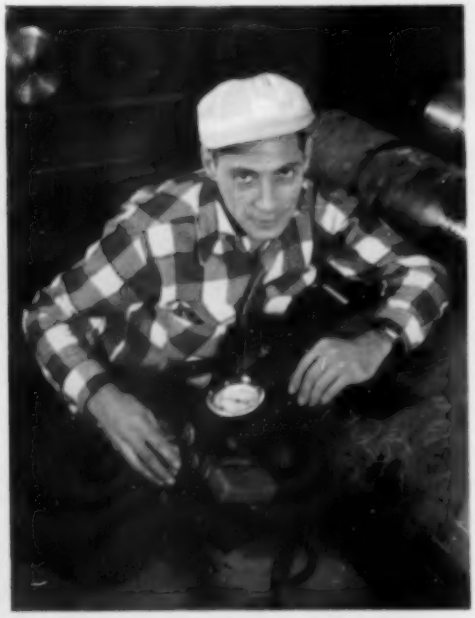
SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

5-271

UNITED STATES STEEL

"We never take a chance

on a hardness check"



—says Kenneth Strang,

U. S. STEEL INSPECTOR

As a U.S. Steel Inspector for 18 years, Kenneth Strang realizes the importance of an accurate hardness check.

Part of this is due to the fact that our own plants use such a great number of hardened steel work rolls. Our numerous cold reduction mills act as a testing ground for every production process and inspection! When you buy a forged steel roll from United States Steel, you get the same unparalleled quality that goes into our own mills.

Before final grinding and shipment, each roll is checked from one end to the other to determine the exact hardness pattern, and to make sure it conforms to the customer's specifications.

Of course, hardness checking is only one of many inspections that are made to insure the usual Homestead Quality Forging. Rolls are a premium product with us, and they are treated as such in every step from the electric furnace ingot to the finished product. The steel, the men who process it, and the equipment they use are carefully coordinated to give you the best forged roll that you can buy.

We solicit your inquiries. For a free 32-page booklet that describes USS Quality Forgings, write to United States Steel, Room 4631, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS *Quality* FORGINGS

- heavy machinery parts—carbon, alloy, stainless
- forged steel rolls and back-up roll sleeves
- electrical and water wheel shafts
- hammer bases and columns

Heroult
ELECTRIC MELTING FURNACES

TOPS FOR PRODUCTION OF HIGH GRADE STAINLESS, ALLOY AND RIMMING STEELS

World's Largest Electric Furnaces

. . . now in operation!

INSTALLED in the ultra-modern mill of McLouth Steel Corporation, in Detroit, these giant *200-Ton* Heroults are the largest electric melting furnaces ever built. With an inside shell diameter of 24'6", they have a rated charge capacity of 400,000 pounds, and each is designed for efficient operation on 25,000 to 33,000 KVA transformer capacity. Featuring a swing-type roof, these furnaces are equipped with the finest, most up-to-date mechanism and electrical controls available.

McLouth's adoption of electric furnaces of this size sets a precedent. It is a "first" which should conclusively prove that, in addition to closer control, higher uniformity, better performance, and greater safety, large capacity Heroult Electric Furnaces are an economically sound investment—even for high tonnage steel-making.

We welcome an opportunity to help you select and install the furnace best suited to your particular requirements.

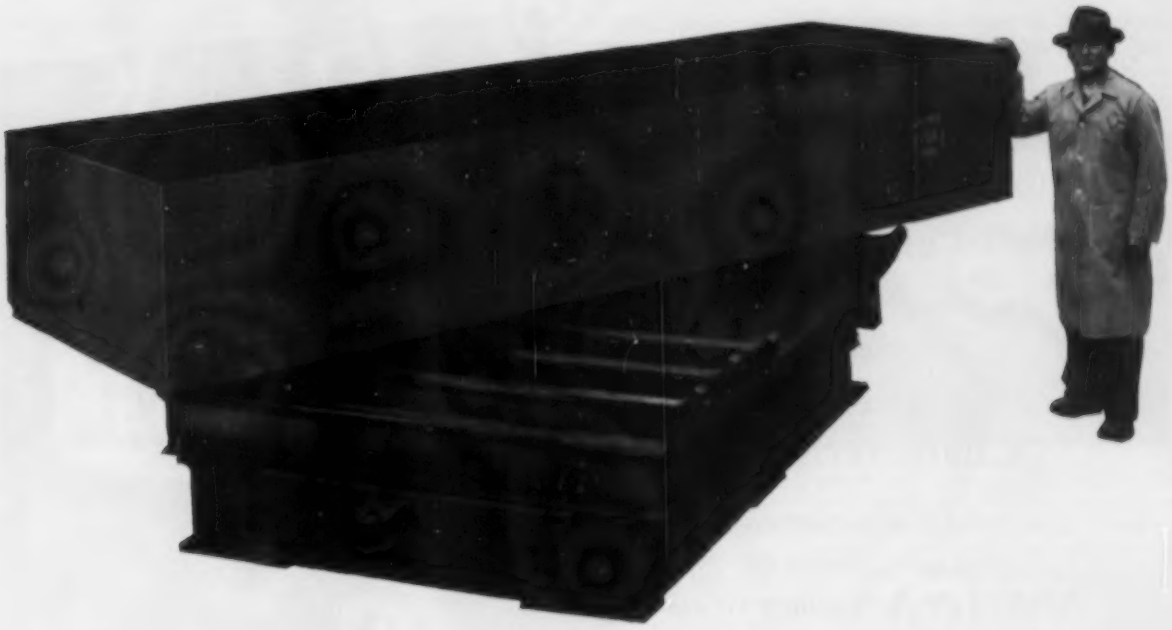
ASK FOR NEW CATALOGUE. *Contains latest information on modern electric furnaces—types, sizes, capacities, rating, etc. Write Pittsburgh Office for free copy.*

AMERICAN BRIDGE DIVISION, UNITED STATES STEEL CORPORATION
GENERAL OFFICES: 525 WILLIAM PENN PLACE, PITTSBURGH, PA.

Contracting Offices in New York, Philadelphia, Chicago, San Francisco and other principal cities.
United States Steel Export Company, New York

USS

UNITED STATES STEEL



What a 26 TON DIE BLOCK means to you!

Actually weighing 52,980 pounds with dimensions 25″ x 48″ x 156″, the die block shown above was one of eight which were made for forging aircraft parts. All of the dies are still producing close dimensional forgings.

What does that mean to you? It means that you can place absolute confidence in the workmanship and materials that go into any Finkl product whether large or small. To make a die block or forging of this size and quality requires the utmost skill and knowledge of steel and its characteristics. This is apparent in every phase of the operation from our own electric steel furnaces through forging, heat treating, machining and inspection.

For 75 years Finkl has been proving that the best is the least costly in the long run by manufacturing only the finest in forgings and die blocks. Call one of the offices listed below the next time you are considering die blocks or forgings. There is no obligation and should you choose Finkl, you will choose the best.

Write for this free catalog telling all about Finkl die blocks and forgings, the types of steel, the proper selection for the job, how to make dies last longer, and many other helpful facts. Please send request on your company's letterhead.

DETROIT 26: 2838 Book Bldg, WOodward 1-1315 • **CLEVELAND 14:** 1914 NBC Bldg, CHerry 1-2939 • **PITTSBURGH 22:** 762 Gateway Center, ATlantic 1-6391 • **INDIANAPOLIS 5:** 132 East 30th Street, Hickory 4647 • **HOUSTON 1:** P.O. Box 1891, CApitol 2121 • **ALLENTOWN:** 737 North 22nd Street, HEmlock 4-3333 • **ST. PAUL 1:** 445 Endicott Bldg, CApitol 2-1600 • **COLORADO SPRINGS:** 534 West Cheyenne Road, MElrose 2-0431 • **SAN FRANCISCO 5:** Monadnock Bldg, EXbrook 2-7018 • **SEATTLE 4:** 3104 Smith Tower, SENeca 5393 • **BIRMINGHAM:** P.O. Box 1606, 7-1603 • **KANSAS CITY 6:** 950 Diercks Bldg, HARrison 1060 • *Western warehouse* **LOS ANGELES 29:** 1001 N. Vermont Avenue, NOrmandy 3-2141 • *Eastern warehouse* **EAST CAMBRIDGE 41, MASS:** 250 Bent Street, ELliot 4-7650

A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE • CHICAGO 14

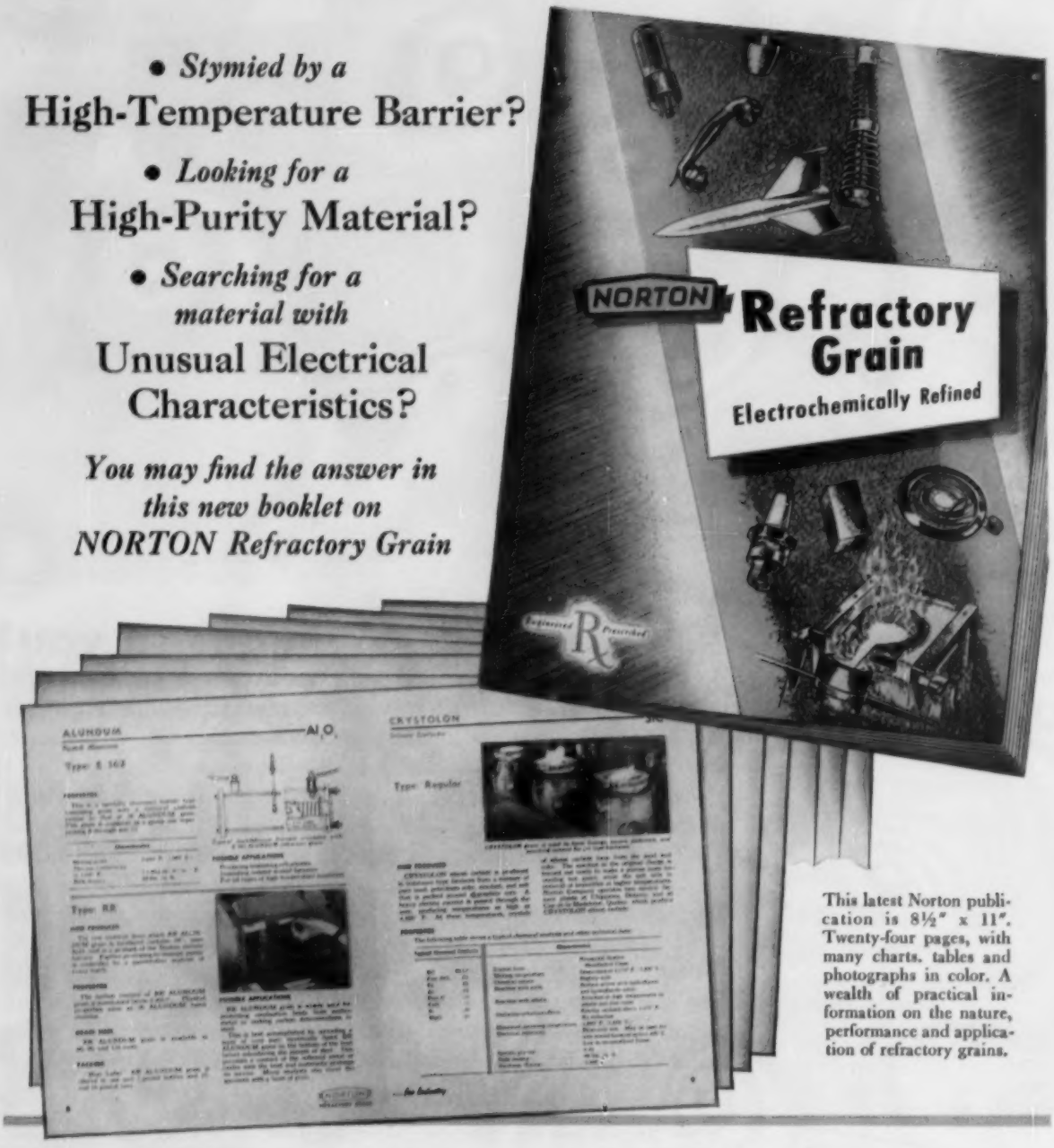
FORGINGS • DIE BLOCKS • ELECTRIC FURNACE STEELS

• *Stymied by a*
High-Temperature Barrier?

• *Looking for a*
High-Purity Material?

• *Searching for a material with*
Unusual Electrical Characteristics?

You may find the answer in this new booklet on NORTON Refractory Grain



This latest Norton publication is 8½" x 11". Twenty-four pages, with many charts, tables and photographs in color. A wealth of practical information on the nature, performance and application of refractory grains.

IF you're concerned with industrial processing involving temperatures ranging upwards to 4000°C and materials to contain your inferno — if you're looking for a high-purity material such as high-purity fused alumina for coating electronic heater filaments — if you're searching for a material with unusual electrical characteristics such as E 179 CRYSTOLON* Silicon Carbide for lightning arrestors — one of the many types of Norton Refractory Grain available may solve your problem.

This new booklet describes in detail Norton Refractory Grain — produced and purified in electric arc and high temperature resistance furnaces — which is helping industry to improve existing products and processes and to create new ones.

It's a valuable reference book with up-to-the-minute information on the chemical and physical characteristics of such materials as CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, Fused Zirconia and Boron Carbide. In it you'll find data on how these materials are produced; their behavior under varying conditions; available grain size and applications.

These electrochemically refined materials may be just what you've been looking for to solve your problem. Write today for your free copy of "Norton Refractory Grain." NORTON COMPANY, Refractories Division, 321 New Bond Street, Worcester 6, Mass.

NORTON
REFRACTORIES
Engineered... Rx ... Prescribed

Making better products... to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

any heat source or forced air, leaving Porcenell on the surface in a uniform layer of the desired thickness. The ware is then charged into a furnace and the coating fused by bringing it to the temperature specified for the particular Porcenell, never more than 1250° F. For cast, wrought, and malleable iron, and heavy sections in general, only the coating itself need be brought up to the fusion temperature.

For further information circle No. 316 on literature request card on p. 36-B.

Variable-Ratio Gas Regulator

North American Mfg. Co. has announced a variable ratio gas regulator for use with burners that operate on lean air-gas ratios at low firing rates. Although the regulator may be used as a standard cross-connected air-gas ratio regulator, it features a special adjustment that permits a negative setting as high as 6 osi. By setting the regulator negative, cross-connecting to the main air line, and adjusting the limiting orifice gas valve for correct air-gas ratio on high fire, an arrangement is established which gives a progressively leaner air-gas ratio as the main air is turned down. This automatic use of excess air at lower firing rates maintains the temperature uniformity when the burners are operated at less than maximum firing rates. Regulators are offered in pipe sizes ranging from ¾ to 3 in. They handle inlet gas pressures up to 3 psi., but give best performance if gas pressures do not exceed 1 psi.

For further information circle No. 317 on literature request card on p. 36-B.

Furnace Mechanization

Special material-handling equipment recently developed for transferring tubular steel products through a continuous normalizing and annealing furnace has been announced by York-Gillespie Mfg. Co. First installation of this furnace equipment has been put in successful operation in the new heat treating line at Jones & Laughlin Steel Corporation's Aliquippa Works, for processing high-strength pipe for deep oil wells. The new equipment rotates the tubes as they move through the furnace. The design permits a full sealed hearth in a conventional furnace, which affords uniform controlled heating of the product and prevents chill spots from developing. Skewed rollers rotate the product as it enters the hot zone of the furnace, thereby minimizing warpage. Specially-designed racks in the furnace proper keep the product properly

spaced and rotate it automatically as it is transferred. A kickoff mechanism is electrically controlled and timed to remove the product from the furnace entry table and deposit it on the furnace racks.

For further information circle No. 318 on literature request card on p. 36-B.

Abrasive Cutting

A new dry abrasive cutting machine, capable of a speed of approximately 3 sec. per sq. in. of material being cut, has been announced by the Campbell Machine Division, American Chain &

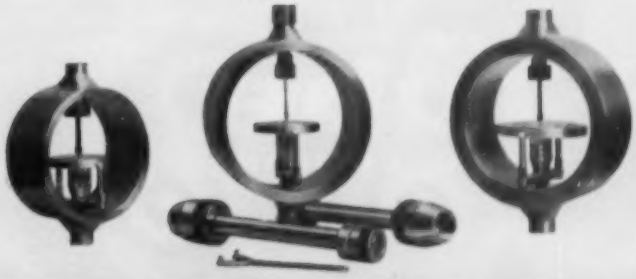
Morehouse PROVING RINGS FOR PRECISION WEIGHING AND CALIBRATING TESTING MACHINES

- Accuracy of 1/10 of 1% is assured for many years by simple yet rugged design.
- Meets all Army, Navy, Federal and A.S.T.M. specifications for calibrating testing machines.
- Certified by the National Bureau of Standards.

CAPACITIES TO COVER A RANGE OF:

Compression Type	Tension and Compression Type
100 to 300,000 lbs. or Equivalent in Kilograms	200 to 100,000 lbs. or Equivalent in Kilograms

- We invite your inquiries concerning special applications and precision weighing problems.



Write for bulletin P-50.

MOREHOUSE MACHINE CO. 233 W. MARKET ST. YORK, PENNA.

IF YOU HAVE NEVER USED THIS ECONOMICAL BRAZED BRASS TUBING

Resolve to Cut Tubing Costs with H&H METALFLO in 1955

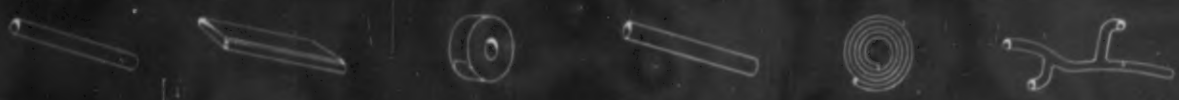
If you want to "earn more than in '54," why not try to cut down on tubing costs? Switching to H & H METALFLO for example, can save you *more* money than you think. An economical brazed brass tubing, it is intended for use where pressure is not the primary consideration. Look around you right now. No matter what you manufacture, there may be an opportunity for you to use METALFLO instead of a seamless or other tube which may be boosting your costs unnecessarily. So remember, to make 1955 a truly *profitable* year, why not investigate the possibility of using more METALFLO, the tubing that was originated, and is now being made exclusively by H & H Tube.

Originators and Sole Makers of METALFLO Tubing

Expect the BEST brass and copper products from

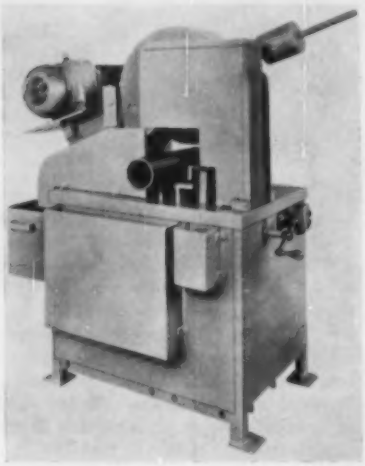
H & H Tube
AND MANUFACTURING COMPANY

256 N. Forman Avenue, Detroit 17, Michigan · Offices from Coast to Coast



METALFLO | LOCKSEAM | COIL STRIP AND SEAMLESS TUBING | TUBULAR PARTS

Cable. It is available in both stationary and portable types. This abrasive cutting machine will handle material up to 4 in. square at 90° to axis for solid steel, 8 in. x 90° to axis for channels. These specifications are



based on using an 18-in. dia. cutting wheel with a 10 hp. motor. Since it is an oscillating type machine, the amount of abrasive wheel contact is reduced and cutting is done with a minimum of pressure of the abrasive wheel. The Sever-All measures 56 x 32 x 62 in.

For further information circle No. 319 on literature request card on p. 36-B.

Portable Induction Heater

Lepel High Frequency Laboratories have announced a high-frequency heating unit combining an induction heating generator with a refrigerating water recirculator. This combination unit can be easily moved about the plant to any location where it may be needed. Once filled, there is no water consumption at all since the water in the unit is constantly refrigerated and

recirculated. The high frequency generator is designed to permit the use of long flexible leads between the unit and the work coil. This feature is invaluable in cases where the work to be done is at a distance from the generator. This unit can be used for soldering, brazing and heat treating ferrous and nonferrous metals. Lepel Model RRP operates on 110 to 220 v. single phase and contains a stepless Thyratron power control to select the proper power output.

For further information circle No. 320 on literature request card on p. 36-B.

Recording Controller

A recording controller has been announced by Thermo Electric Co. The new instrument records on a circular, 12-in. chart and has either two-position or pulse-proportional control action. Two-position control turns heat on when temperature is below the control point and cuts heat off when temperature exceeds it. It is recommended for batch and other processes having similar control characteristics and where temperature changes can be detected quickly by the thermocouple or resistance bulb. Pulse—proportional control changes heat input according to the magnitude of temperature change. Its proportion band is continuously adjustable from 0 to 20%. It is recommended for continuous and other processes having similar control characteristics. Potentiometer pyrometer and resistance thermometer controllers are used.

For further information circle No. 321 on literature request card on p. 36-B.

Filters

Comco, Inc., has announced a new series of cartridge-type filter units designed for the electroplating and electroforming industries. The units are available in a variety of models ranging from 100 to 5000 gal. or more per hour. They are available in iron, stainless steel, rubber and plastic for use with all types of corrosive solutions.

For further information circle No. 322 on literature request card on p. 36-B.

Ultrasonic Inspection

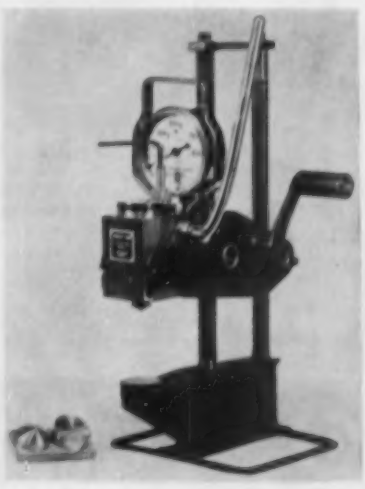
Vibro-Ceramics Corp. has announced an ultrasonic attenuation analyzer, which enables one to determine internal changes of structure or detect internal flaws and irregularities. The analyzer operates by placing a small transducer against the material to be tested. The transducer beams a short ultrasonic signal through the material. The analyzer then records the return pulses reflected by the material. Sev-

eral sets of information are obtained: 1. The attenuation of ultrasonic signal. 2. Its characteristic velocity. 3. The shape of the reflected pulses. The sample must be sufficiently thick to prevent the leading edge of the ultrasonic pulse from overlapping its own trailing edge at the input boundary or surface. It is recommended that the sample be at least ¼ in. thick, and the ideal range is from ½ in. to 2 in. The ultrasonic frequency works best within a range of 3 megacycles to 300 megacycles. The most practical frequency range runs from 5 to 100 megacycles.

For further information circle No. 323 on literature request card on p. 36-B.

Hardness

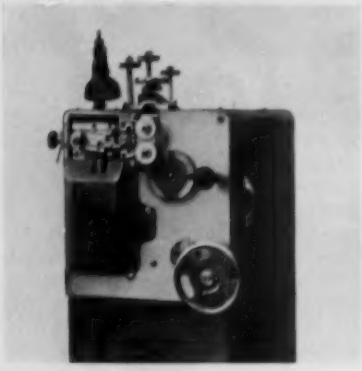
A portable hardness tester for making Brinell tests on nonferrous alloys has been announced by Andrew King. The removable test head makes it possible to test parts of any size or shape and the instrument can be used in any position, even upside down, with or without the base. The King Portable can be set at 62½ kg., 125 kg., 250 kg., 500 kg., 750 kg. and 1000 kg.—the maximum load that can be applied. 5 mm. and 10 mm. balls are used for various applications and



where a small impression is desirable, a 5 mm. ball with a 750 kg. load will cover the same hardness range as a 10 mm. ball and a load of 3000 kg.
For further information circle No. 324 on literature request card on p. 36-B.

Springmaking Machines

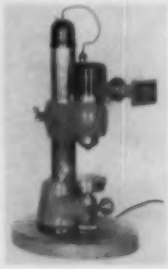
Torrington Mfg. Co. has announced a new Springmaker. Weighing 695 lb., the machine can handle 0.008 to



0.028-in. wire ranging up to 24 in. in length. Outside diameter of the machine's coils range from 1/16 to ⅞ in. It will produce from 24 to 243 springs per minute with a motorized variable speed transmission and from 21 to 240 with an electronic adjustable drive.
For further information circle No. 325 on literature request card on p. 36-B.

Measuring Surface Roughness

An interference microscope which will measure smoothness or roughness of polished, lapped and ground surfaces of any material has been announced by Farrand Optical Co. It is a high-power, high-resolution, optical instrument adaptable for either visual or photographic use. The microscope will measure roughness to 1 micro-inch.



For further information circle No. 326 on literature request card on p. 36-B.

Laboratory Vacuum Furnace

Consolidated Vacuum Corp. has announced a new 5 to 50 lb. high vacuum melting and casting furnace. Large vacuum pumping capacity is provided by the two stage diffusion-ejector pump which creates the low pressures required for a gas-free atmosphere

and provides ample capacity for handling the pressure surges that occur during alloy additions and pouring. The induction heating unit is mounted in the permanent portion of the furnace chamber and is so positioned that the crucible can be easily charged with the chamber open or through an overhead port with the chamber closed. There is a choice of five crucible sizes to accommodate melts of 5, 12, 17, 30 and 50 lb.
For further information circle No. 327 on literature request card on p. 36-B.

Carbide-Tipped Mills

Carbide-tipped end mills and shell mills with helical teeth have been announced by Wendt-Sonis Co. Helical

Announcing THE X-TRON 180

the most versatile, U.S. made, high powered unit for x-ray of pipe lines, tanks, boilers, castings

WHAT IT IS

The X-TRON 180 is a light weight, portable industrial x-ray unit. It contains a specially designed transformer and x-ray tube and a high voltage generator that delivers 200 K.V. and 15 M.A. continuously. The x-ray tube is of the end ground type with a 360° target that permits complete circumferential x-ray.

WHERE IT IS USED

This versatile, U.S. made x-ray unit is used to inspect weldments and construction of pipe lines, tanks, boilers, castings and other equipment in the field and in industrial plants and on ships. It will penetrate 21/8" of steel and easily gets into small spaces.

The X-TRON 180 will traverse a pipe line greater than 12" in diameter and can be placed inside a ring of castings so that they all can be x-rayed at one time.

Optional equipment permits even greater flexibility of application.

FEATURES

In order to do all of its many jobs, the X-TRON 180 must have many important advantages . . . and it does—10 in all.

Write, wire or call and we'll be glad to give you a description of these advantages plus any additional information you may require.

MITCHELL RADIATION PRODUCTS CORP.

128 E. Washington Street, Norristown, Pa. Norristown 5-7962

teeth maintain a constant cutting relation with the workpiece. The life of these new cutting tools is reported to be increased two to three times as tool

shock is reduced when helical teeth engage the work. Sizes offered are from ⅛ to 2 in. for end mills, and from 1¼ to 6 in. diameter for shell mills.

For further information circle No. 328 on literature request card on p. 36-B.

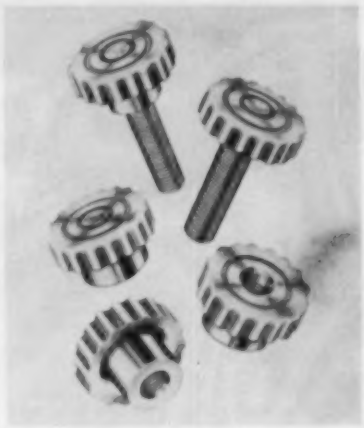
Refractory

J. H. France Refractories Co. has announced a new extra strength castable refractory. Laboratory tests results and service reports indicate the new product develops almost twice the cold set strength of standard 2450° F. castables at room temperatures. At 2000° F. the product develops over twice the crushing strength of a regular 2450° F. castable. The manufacturer recommends its use in annealing furnace car bottoms, hood annealing bases, warming or holding pits, door linings, carburetor linings and uptakes and in blow-off linings.

For further information circle No. 329 on literature request card on p. 36-B.

Fasteners

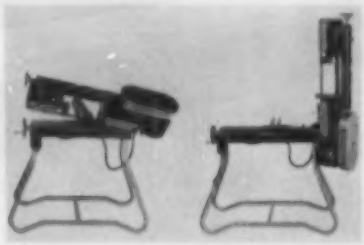
Die-cast round-head thumb nuts and screws for replacement or adjustment applications have just been announced by Gries Reproducer Corp. Designed with an unusually wide head for ease of grip, and cast in zinc alloy, they are an entirely new type of standard threaded fasteners. They are rustproof and corrosion resistant and uniform in size and shape.



For further information circle No. 330 on literature request card on p. 36-B.

Band Saw

The development of a new dual purpose metal cutting band saw has been announced by Wells Mfg. Corp. It is designed for use either as a horizontal or an upright band saw. The blade is driven by a ¼ hp., 115 v. motor, controlled by a manual switch with automatic shut-off at the end of each cut. It has a V-belt drive with selective speeds of 54, 100 and 190 fpm. The frame and bed are welded steel and mounted on tubular steel legs.



For further information circle No. 331 on literature request card on p. 36-B.

PERECO
Roller Hearth
Electric
FURNACE

Easier Handling of Heavy Loads

This new Model No. RH-48 PERECO Electric Roller Hearth Furnace is especially designed for rapid and easy handling of large or heavy loads, such as tools, dies, or products of similar nature which are difficult to load or unload from a hot furnaces. Also ideally suited for enameling on bulky or heavy metal items. Typical of all Pereco Furnaces built to specialized job-requirement, automatic temperature controls of all standard makes are available to meet the individual need. Tell us your need and let us propose the answer.

Standard and Special Units 450° to 5000° F.

Write Today For Catalog

PERENY EQUIPMENT CO.
Dept. Q. 893 Chambers Rd., Columbus 12, Ohio

OSTUCO internally upset tubing processes faster

Saves $4.95 per unit

DETAILED DRAWING OF UPSET

INTERNALLY UPSET OSTUCO TUBING

COMPLETED GEAR ASSEMBLY

Landing gears, manufactured by The Cleveland Pneumatic Tool Company for North American Aviation's F-86H, have piston tubes machined from internally upset OSTUCO tubing. The upset construction of these *special-quality* OSTUCO tube forgings keeps machining to a minimum and permits faster processing. Savings are 25% . . . or $4.95 per unit.

Special-quality OSTUCO tubing produces stronger, lighter products . . . better looking products at greater savings. Its uses are practically unlimited. Wherever you use tubing *in any form*, OSTUCO's single source service can save you time and money. Write for helpful booklet "Ostuco Tubing," or better still, send us your blueprints for immediate quotation.

OSTUCO SHELBY, OHIO **OSTUCO TUBING**

SEAMLESS AND ELECTRIC WELDED STEEL TUBING —Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America
SALES OFFICES: BEVERLY HILLS • BIRMINGHAM • CHARLOTTE CHICAGO • CLEVELAND • DAYTON • DETROIT • HOUSTON LOUISVILLE • MOLINE • NEW YORK • PHILADELPHIA PITTSBURGH • ROCHESTER • ST. PAUL • SEATTLE TULSA • WICHITA
CANADA, RAILWAY & POWER CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY 117 Liberty Street, New York 6, New York

WHAT'S NEW
IN MANUFACTURERS' LITERATURE

351. Abrasives
Booklet No. 14 on abrasive grain and powders for use in metal finishing. *Carborundum Co.*

352. Abrasives
Folder on abrasive chips and compounds for barrel finishing. *Minnesota Mining and Mfg.*

353. Alloy Castings
Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

354. Alloy Selection
Chart to select alloy for given corrosive problem. 350 corrosives included. *Cooper Alloy Foundry*

355. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

356. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

357. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

358. Alloy Steel
40-page book on applications of heat treated, special alloy steel. *Jones & Laughlin*

359. Alloy Steels
Comparative tables of SAE and AISI standard steels and tentative standard steels. *Babcock & Wilcox*

360. Aluminum
Brochure with actual aluminum part attached gives advantages of aluminum for screw machine stock. *Kaiser Aluminum & Chemical Sales*

361. Aluminum
12-page booklet on extruded shapes, tube and pipe, coiled sheet, forgings and properties of aluminum alloys. *Revere*

362. Aluminum Alloys
62-page catalog gives standard aluminum products and new alloy designation system. Tables of chemical compositions, sheet bending. *Adam Metal Supply*

363. Aluminum Bonding
Brochure on Alumi-coat process of bonding aluminum and its alloys to ferrous metals. *Arthur Tickle Eng'g. Works*

364. Aluminum Bronze
Folder on the vacuum die casting process and castings made by it. *Aurora Metal Co.*

365. Aluminum Cleaning
48-page booklet gives practical tips on materials and methods of cleaning aluminum and magnesium. *Oakite*

366. Aluminum Coating
Article on hot dip coating of ferrous metals with aluminum and aluminum alloys from "Tips and Trends". *Ajax Electric*

367. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

368. Annealing Titanium
Data on annealing titanium parts in high vacuum furnace. *High Vacuum Equipment Corp.*

369. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

370. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

371. Atmospheres
New 12-page bulletin on use of protective atmosphere to prevent deterioration of metals during various heat treating processes. *General Electric*

372. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

373. Automatic Polishing
14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

374. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

375. Barrel Finishing
12-page booklet on techniques and products. How it works, parts that can be barrel finished and operations the method performs. *Minnesota Mining and Mfg. Co.*

376. Bearings
New 44-page catalog and manual on self-lubricating products including bearings, bushings, machine parts. *Wakefield Bearing Corp.*

377. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses and gives engineering data. *W. M. Chace*

378. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

379. Blackening Compounds
Bulletin on blackening compounds for ferrous alloys to AMS Spec 2485. *Swift Industrial Chemical*

380. Blast Cleaning
Bulletin describes new Rotoblast wheel used in blast cleaning and dust control equipment. *Pangborn*

381. Bonded Metals
Data on advantages of parts of bonded aluminum and steel. *Al-Fin Div.*

382. Brass Tubing
Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

383. Brazing
Bulletin 5889 on furnace and induction brazing installations and methods. *General Electric*

384. Brazing
24-page Bulletin 20 on advantages of Easy-Flo silver brazing alloy, with information about joint design and fast production methods. *Handy & Harman*

385. Brazing Aluminum
12-page bulletin, ADR 45, on how to torch braze aluminum and strength of joints so brazed. *Air Reduction Sales*

386. Burners
Bulletin 123 on new series of burners for multi-purpose furnaces. *North American Mfg.*

387. Calibrating System
Data on weighing and calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

350. Copper Alloy Specifications
This new index gives ASTM, SAE, AMS, Federal, Military and Navy specifications designations for various forms of copper, brasses, leaded brasses,

phosphor bronzes, aluminum bronzes, cadmium bronzes, copper-silicon alloys, cupro nickels, nickel silvers and special alloys. Listings are made by product and by specification number. *American Brass Co.*

388. Carbides
84-page catalog of sintered carbides, hot pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

389. Carbon Control
Bulletin SC-168 on system for automatically controlling carbon potential in continuous and batch furnaces. *Surface Combustion Corp.*

390. Carbon Control
Bulletin C-22 and reprint on Carbotronik for automatic control of carbon potential of atmospheres. *Ipsen*

391. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

392. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

J&L Scrapless Nut Wire
helps close production gaps

Even with the best equipment and know-how, your scrapless nut production is only as good as the wire you use.

For smooth production that makes every minute count, you can rely on J&L scrapless nut wire. Quality controlled in every phase of manufacture, J&L scrapless nut wire gives you the best in—

- SURFACE QUALITIES
- WORKABILITY
- UNIFORMITY
- FINISH

Down-time is costly—keep it to a minimum and boost your overall production of a better finished product with J&L scrapless nut wire. Remember—wherever you're located, you'll find the J&L representative near you can help show the way to fewer rejects, less die wear and less machine down-time. Call him today or write: Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pa.

Jones & Laughlin
STEEL CORPORATION — *Pittsburgh*

J&L STEEL

J&L SCRAPLESS NUT WIRE—TOPS IN QUALITY... COMPETITIVE IN PRICE

393. Carburizing
Reprint of article on increase in production due to changing from pack carburizing to liquid carburizing. *American Cyanamid*

394. Casehardening
32-page booklet on casehardening of steel by nitriding. *Armour Ammonia Div.*

395. Cemented Carbides
16-page bulletin gives mechanical and physical properties of carbides for tools and high-temperatures. *Kennametal*

396. Cemented Carbides
New 20-page catalog of complete line of cemented carbide blanks. *Firth-Loach Metals, Inc.*

397. Centrifugal Castings
Booklet on spun centrifugal castings of bronze for liners, rings, rolls, sleeves, bushings. *American Non-Gran Bronze*

398. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

399. Cleaners
Bulletins on di-phase cleaners, specifications, equipment, advantages. *Solventol*

400. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

401. Cleaning
Bulletin on finishing and cleaning prior to electroplating by pressure blasting. *Cro-Plate Co.*

402. Cleaning
32-page booklet on alkaline, solvent, emulsion, acid phosphate cleaning. *E. F. Houghton*

403. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

404. Cobalt Alloy
12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

405. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

406. Continuous Cast Bronze
12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining.*

407. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

408. Controlled Atmospheres
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

409. Copper Plating
24-page manual on bright copper-plating process. Process control, analytical procedures, barrel plating are discussed. *Lea Mfg. Co.*

410. Corrosion of Copper
28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

411. Corrosion Resistance
20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

412. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

413. Cutting Fluid
"Metal Talk" describes No. 122 clorinated wax-cut and its advantages in lathe work. *S. C. Johnson*

414. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

415. Cutting Tools
36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

416. Deburring
Bulletin on deburring by pressure blast and equipment for wet pressure blasting. *Cro-Plate Co.*

417. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

418. Degreasing
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

419. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

420. Dew-Point Recorder
Bulletin 407 and Data Sheet AED 340-7 on dew-point systems for recording or controlling. *Foxboro*

421. Diamond Abrasive
4-page folder on the advantages of diamond abrasives for polishing metallurgical specimens. *Buehler, Ltd.*

422. Diamond Wheel
Bulletin on advantages of diamond wheel grinding. *Action Diamond Tool*

423. Die Casting
Bulletin on new die casting machine with new clamp design and injection end. *Hydraulic Press Mfg. Co.*

424. Die Casting
30-page booklet of pressure die casting, permanent mold casting and centrifugal casting of copper base alloys. *Pressco Casting & Mfg.*

425. Die Castings
20-page bulletin on the process, design and construction. Uses of die castings. *Precision Castings Co.*

426. Dielectric Heating
New bulletin on dielectric heaters and their advantages. *Allis-Chalmers Mfg.*

427. Dryers
24-page bulletin No. 222 shows installations of air drying equipment in various industries. *Pittsburgh Lectrodryer*

428. Electric Arc Furnace
Carbon and Graphite News contains an article on the electric arc furnace, an appraisal for management. *National Carbon*

429. Electric Furnaces
8-page booklet on belt conveyor electric furnaces for bright hardening. *Westinghouse Electric Corp.*

430. Electric Furnaces
Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

431. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

432. Electrodes
36-page booklet on low alloy and mild steel electrodes. Engineering tables of SAE steels, preheating temperatures, estimating cost of welding, hardness of welds. *Metal & Thermit*

433. Electroplated Platinum
Data sheets of information helpful in electroplating palladium and platinum. *Technic*

434. Enamel
Brochure describes complete process of enamelling. Analysis and testing. *Chicago Vitreous Enamel Product Co.*

435. Extrusion Presses
8-page bulletin on aluminum extrusion presses describes the process and presses at work. *Watson-Stillman*

436. Extrusions
12-page circular on aluminum extrusion process contains selection data. Process described. Advantages. *Precision Extrusions*

437. Fabrication
Booklet on welded steel heavy fabrication pictures and describes how various products are made. *R. C. Mahon*

438. Fasteners
12-page bulletin on special rivets, nails, screws and small parts manufactured by cold heading process. *John Hassall, Inc.*

439. Ferro-Alloys
32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

440. Filters
Bulletin on application of industrial filters to oil quenching process. Experience with two applications. *Industrial Filtration Co.*

441. Finishing
52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

442. Finishing
Bulletin B-4 on burnishing compound for aluminum and brass. *Apothecaries Hall*

443. Finishing
New bulletin on chemicals for metal protection and paint bonding on aluminum, zinc and steel. *American Chemical Paint*

444. Flame Cutting
Bulletins on torch tips for flame cutting with propane gas. *Flame Cutting Equipment*

445. Flame Hardening
20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

446. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g.*

447. Forging Hammers
24-page brochure describes construction and use of steam drop hammers. *Erie Foundry*

448. Forgings
Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

449. Forgings
20-page booklet on forgings. Sections on nomenclature, design layout, die design and tolerance tables. *Consolidated Industries, Inc.*

450. Forgings
94-page book on die blocks and heavy-

ARCOS FOR FINEST QUALITY WELDS

Submerged Arc Welding of Stainless with **new** Arcosite Flux

Now, for the first time, you can apply the economy of submerged arc welding to stainless steels. No longer need you worry about cracking, or poor transfer of the essential stainless elements. The combination of *new* ARCOSITE FLUX and *new* ARCOS CHROMAR (Stainless Steel) WIRE provides a balanced analysis for sound, dependable welds on every job. It's another example of how Arcos experience with coated electrodes and weld metallurgy is being translated into tangible benefits for you.

Write today for the Arcosite Flux Bulletin and see how you may profit from these two *new* Arcos products. Arcos Corporation, 1500 South 50th Street, Philadelphia 43, Pennsylvania.

WELD WITH ARCOS

STAINLESS WIRE AND ARCOSITE FLUX

duty forgings. 20 pages of tables. *A. Finkl & Sons*

451. Forming
36-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling, tooling needed. *Yoder*

452. Foundry Practice
20-page Lavingot Journal No. 10 gives chart on specifications and test bar designs of nonferrous ingot and casting alloys. *Lavin*

453. Freezer
Data on chest for use down to -95° F. for production use and testing. *Revco*

454. Furnace Controls
22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

455. Furnace Insulation
Bulletin on ceramic fiber that can give impressive savings compared with high-quality insulating brick. *Refractories Div., Carborundum Co.*

456. Furnaces
16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

457. Furnaces
8-page bulletin on continuous, car-type, reverberatory, recirculating and other furnaces. *Demsey Industrial Furnace*

458. Furnaces
Data on electric furnaces of top or side loading types. *Lucifer Furnaces*

459. Furnaces
High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

460. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

461. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

462. Furnaces, Heat Treating
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

463. Furnaces, Rotary Hearth
Folder giving drawings, dimensions, capacity, Btu. required for drawing, annealing, forging. *Gas Machinery*

464. Gamma Radiography
8-page catalog on gamma-ray radiography with radioactive cobalt 60 and iridium 192. *Mitchell Radiation Products*

465. Gas Analysis
Data on positive, nondispersion-type infrared analyzers for laboratory and industry. *Minneapolis-Honeywell*

466. Gas Heaters
20-page bulletin on immersion heaters, dynamic dryers, inert gas generators. *C. M. Kemp Mfg.*

467. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

468. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

469. Grinding Wheel
Bulletin on bonded diamond impregnated grinding wheel for fast grinding. *A. I. T. Diamond Tool Co.*

470. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

471. Hard Facing
4-page bulletin on Spraywelder and the Sprayweld process. *Wall Colmonoy*

472. Hard Surfacing
40-page hardfacing manual tells what metals can be hardfaced, how to select right hardfacing material, lists step-by-step procedures and industrial applications. *Haynes Stellite*

473. Hardening Stainless
24-page "Story of Malcomizing" describes surface hardening of stainless steels. *Lindberg Steel Treating Co.*

474. Hardness Conversion
Wallet-size celluloid card gives hardness and tensile conversions. *International Nickel*

475. Hardness Tester
Bulletin RH-12-54 on portable hardness tester for Rockwell readings. *Riehle*

476. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

477. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

478. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

479. Hardness Tester
Data on hardness tester using three colored lights to indicate relative hardness. *Steel City Testing*

480. Hardness Tester
Bulletin on hardness tester for all regular and superficial Rockwell tests. *Kent Cliff Div., Torsion Balance Co.*

481. Hardness Testers
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

482. Hardness Testers
Bulletin No. A-12 on new Wolpert-Gries machine for making Rockwell hardness tests. *Gries Industries*

483. Heat Exchangers
Bulletin No. 120 on exchangers used in cooling or controlling temperatures of industrial liquids. *Niagara Blower*

484. Heat Resistant Alloy
6-page bulletin on high-heat resistant muffles and retorts. *Electro-Alloys*

485. Heat Treating
Folders on steam method of hardening and tempering. Case histories. *Leeds & Northrup*

486. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low temperature processing. *Young Bros.*

487. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanicood*

488. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

489. Heat Treating Baskets
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

490. Heat Treating Belts
Catalog of conveyor belts and data

ARCOS FOR FINEST QUALITY WELDS

Mountains crumble as ***welded*** *jaws bite in*

Modern power shovels gulp truckloads of rock and dirt at one bite. It's a good example of how *welded* high tensile steels make possible bigger payloads—provide extra strength and toughness to reduce maintenance.

An important factor in this achievement is the quality of weld metal. That's why so many fabricators today specify Arcos Low Hydrogen Electrodes when welding low alloy high tensile steels. *On any job* demanding shock and abrasion resistance . . . maximum strength and ductility, the excellent properties of Arcos weld metal assures the results you want in service. Arcos offers quality weld metal and technical assistance that is second to none. Arcos Corporation, 1500 South 50th Street, Philadelphia 43, Pa.

WELD WITH ARCOS LOW HYDROGEN ELECTRODES

Only GRAPH-MO® gives you all three advantages in one tool steel

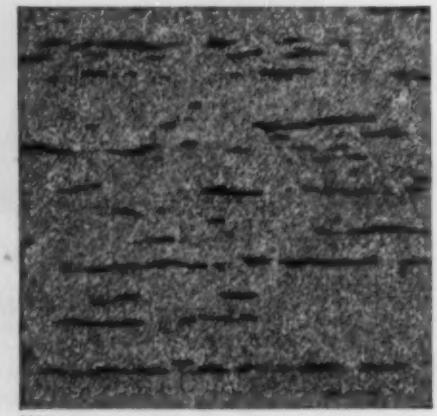
Wearability—*Outwears other tool steels 3 to 1*

Stability—*Is the most stable gage steel ever made*

Machinability—*Cuts machining time 30%*

YOU can make gages and dies that stay accurate longer and produce them in less time by using Graph-Mo® graphitic tool steel. That's because only Graph-Mo gives you the combination of wearability, stability and machinability that you want in a tool steel.

Free graphite and diamond-hard carbides in the structure of Graph-Mo steel give gages and dies extraordinary life. Reports from users show that Graph-Mo outwears other tool steels 3 to 1.



100X

In your plant, Graph-Mo steel will cut production time and rejects. Because of its graphitic structure, Graph-Mo steel machines 30% faster than other tool steels. This structure also gives excellent resistance to abrasion, and has minimum tendency to pick up, scuff or gall. Tests on Amsler Wear Machine show Graph-Mo has twice the resistance to galling when compared with ordinary tool steels.

The greater stability of Graph-Mo steel enables you to make gages that stay accurate longer. After 12 years of service, for example, a typical Graph-Mo steel master plug gage showed less than 10 millionths of an inch change from its original dimensions.

You can always tell Graph-Mo steel by its "graphitic look"—the tiny, scattered, parallel marks barely visible on the surface of a piece of polished Graph-Mo. This built-in "trade-mark", the result of free graphite in its structure, can't be duplicated in ordinary steels. The photomicrograph at left shows the free graphite and diamond-hard carbides that give Graph-Mo unusual wear resistance.

Write today for more information on Graph-Mo steel. The Timken Roller Bearing Company, Steel and Tube Div., Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

for their design, application and selection. *Ashworth Bros.*

491. Heat Treating Fixtures

24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

492. Heat Treating Furnaces

12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

493. Heat Treating Pots

Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

494. Heat Treatment

Bulletin 200 on car hearth, rotary hearth, pit, roller hearth, belt, chain, pusher and "hi-head" furnaces. *R-S Furnace*

495. Heating Elements

24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

496. High-Alloy Castings

Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

497. High-Strength Steel

48-page book on Carilloy T-1. Applications, properties, processing. *U.S. Steel*

498. High-Temperature Lubrication

Bulletin on colloidal graphite lubrication of kiln cars, oven conveyors and forging dies. *Acheson Colloids*

499. Identifying Stainless

Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

500. Induction Heat Control

Data sheet on radiation pyrometer for direct measurement of work being induction heated. *Leeds & Northrup*

501. Induction Heating

60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

502. Induction Heating

A new 8-page bulletin on forging with induction heat includes case histories, benefits to the forging industry. *General Electric*

503. Induction Heating

"Induction Heating" . . . presents case histories of increased production, reduced space, lower costs. *Westinghouse*

504. Induction Heating

40-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

505. Induction Melting

16-page booklet 14-B on high-frequency converter type furnaces for induction heating and melting of ferrous and nonferrous metals. *Ajax Electrothermic*

506. Industrial Fans

Catalogs on various kinds of industrial fans—exhaust, multiblade, backward curve, for high temperatures. *Garden City Fan*

507. Instruments

Bulletin F-5633-1 on instruments for industrial process control. *Wheelco*

508. Instruments

New 24-page catalog 5001 on industrial instruments and equipment. *Minneapolis Honeywell*

509. Investment Castings

New 12-page booklet tells of the development of the investment casting process, its techniques, equipment, advantages and limitations. *Hitchiner Mfg. Co.*

510. Iron-Nickel Alloys

32-page bulletin on austenitic iron-nickel alloys having special thermal expansion or thermo-elastic characteristics. *International Nickel*

511. Laboratory Furnaces

Information and bulletins available along with current price lists on complete assortment of Lindberg laboratory furnaces. *Boder Scientific Co.*

512. Laboratory Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

513. Leaded Steel

New 8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel Co.*

514. Low-Melting Alloys

Booklet on alloys for aluminum matchplates for core box and dryer patterns, for metallizing wood patterns and core boxes. *Cerro de Pasco*

515. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

516. Lubrication

4-page reprint on lubrication properties and industrial applications of pure molybdenum disulfide. *Alpha Corp.*

517. Machinability

48-page booklet based on laboratory and production tests. Property tables, microstructure. *Titan Metal Mfg.*

518. Machining Aluminum

4-page bulletin on machining aluminum covers types and shapes of tool, preparation of drills, tool materials, tapping and threading, reaming, spinning, sawing and lubricants. *George Salt Metals*

519. Machining Steels

Guide to selection of fastest machining steels. *Ryerson*

520. Magnesium Alloys

Loose-leaf folder of data and tables on chemical specifications, properties, extrusion, machining operations. *Brooks and Perkins*

521. Magnetic Particle Test

New 8-page booklet on new portable magnetic test unit. *North American Philips*

522. Magnetic Separators

16-page bulletin on non-electric permanent magnetic separators. *Eriez Mfg. Co.*

523. Melting Furnaces

28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

524. Melting Furnaces

8-page Bulletin 560 describes stationary and tilting types of two-chamber melting furnaces. Applications to all types of casting. *Lindberg Engineering*

525. Metal Cutting

64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

526. Metal Cutting Saw

Bulletin on new, portable band saw and band saw blades. *Wells Mfg. Corp.*

527. Metal Powders

Table lists metals in which powders are available, companies producing them, grades and types. *Metal Powder Association.*

528. Metal Working Presses

Bulletin 502-A on deep drawing hydraulic presses for metal working. *M & N Hydraulic Press Co.*

529. Microhardness Tester

Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

530. Microscopes

Catalog on metallograph and several models of microscopes. *United Scientific*

531. Microscopes

8-page bulletin on several models of metallurgical microscopes. *American Optical*

532. Moly-Sulphide Lubricant

40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

533. Monel

New booklet on engineering properties of cast monel. *International Nickel Co.*

534. Nitriding

48-page booklet on nitralloy and nitriding, including the new Floe process. Types of nitriding steels, surfaces not to be hardened, weldability. *Nitralloy Corp.*

535. Nondestructive Testing

8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

536. Oil Quenching

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

537. Openhearths

Brochure on modern openhearth design and construction. *Loftus*

538. Phase Contrast

16-page Bulletin D-104 on theory, applications and equipment for phase contrast microscopy. *Bausch & Lomb*

539. Phosphate Coating

12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

540. Phosphate Coating

Booklet tells types of phosphate coatings used, and how phosphate coatings are formed. *Metalwash Machinery*

541. Phosphor Bronze

New 4-page bulletin on general information about phosphor bronze strip. *Penn Precision Products*

542. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

543. Plating Racks

New 12-page catalog on insulated plating rack sections and insulated contact tips. How different rack styles can be assembled from an assortment of sections. *Belke Mfg. Co.*

544. Platinum Cladding

Bulletin on how it is made, thickness of cladding, testing, applications. *Baker & Co.*

545. Porous Chromium

12-page bulletin on hard, porous chromium coating for cylinder bores and bearing surfaces. *Van der Horst*

546. Powder Metallurgy

Information on sponge iron powder. *Ekstrand & Tholand*

547. Precision Casting

8-page bulletin on investment castings

(*Continued on page 36A*)

(Continued from p. 35)

of various ferrous and nonferrous alloys. *Engineered Precision Casting*

548. Precision Casting

12-page book on alloy selection and design for precision casting. *Arwood Precision Casting Corp.*

549. Presses

New 6-page bulletin on 150-ton multipurpose, triple action metalworking press. Features and specifications. *Hydraulic Press Mfg.*

550. Program Controllers

Data sheet on Speedomax program control systems for batch-type heating processes. *Leeds & Northrup*

551. Proportional Control

Bulletin F-6493 on proportional position control for fuel fired furnaces and ovens. *Wheelco Instruments Div.*

552. Quenching

New bulletin No. 11 on quenching oil also discusses advantages of quench agitation. *Sun Oil Co.*

553. Quenching

64-page book tells what happens when steel is heated and cooled, describes quenching media, quenching practices, interrupted quenching and cooling methods. *E. F. Houghton*

554. Quenching Oil

10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

555. Quenching Oil

New book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

556. Recirculating Furnace

Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. *Industrial Heating Equipment Co.*

557. Refractories

Booklet on uses of magnesia ramming mix. *Basic Refractories, Inc.*

558. Refractories

24-page booklet on how refractory grain is produced. Chemical and physical characteristics, sizes available, applications. *Norton.*

559. Refractories

12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

560. Resistance Testing

Bulletin 100 on production tester for measuring electrical resistance. *Rubicon*

561. Rhodium Plating

Data on properties, thicknesses required, costs, operation, applications. *Technic*

562. Rod Mills

8-page booklet on tandem mills used for high speed reduction of ferrous and nonferrous rod. *Waterbury Farrel Foundry & Machine*

563. Roll Formed Shapes

24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

564. Rotary Straighteners

Bulletin RS50 on machines for straightening, sizing, polishing bars, tubes and pipe. *Continental Foundry & Machine*

565. Rust Preventives

12-page bulletin on water-soluble rust-preventive. *Production Specialties*

566. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

567. Salt Baths

Data on salt bath hardening of engine parts from Tips and Trends. *Ajax Electric*

568. Salt Baths

New folder on gas fired salt bath furnaces for heat treating and high-production billet heating. *Ankersen Engineering*

569. Saws

Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

570. Shell Thread Rolling

New 4-page bulletin on automatic, inclined, shell thread rolling machine, its use, construction and operation. *Waterbury Farrel Foundry and Machine*

571. Shot and Grit

Handy calculator has size data for SAE grades of shot and grit. *Pangborn*

572. Shotblasting

16-page "Primer on the Use of Shot and Grit." Problems of blast cleaning operations. *Hickman, Williams.*

573. Slitters

New catalog describes operation of slitter and also the machines then *Ohio Knife Co.*

574. Sodium

24-page book on handling sodium laboratory and plant. Application scaling. *Ethyl Corp.*

575. Soldering

New 10-page bulletin on ultrason less soldering and metal coating— and equipment. *Aeroprojects, Inc.*

576. Spark Testing

20-page spark test guide feature diagrams of 13 standard tool a steels. *Carpenter Steel*

577. Spectrograph

20-page catalog describes large spectograph, medium quartz spec and densitometer for spectrum a *Bausch & Lomb*

578. Spectrometer

12-page bulletin on mass spect for continuous analysis. Instrum operation, accessories. *Consolidat gineering*

579. Spectrometry

12-page brochure on quality with a direct reading spectromete *Assoc.*

580. Speed Control

Bulletin on variable speed driv transmitters. *Reeves Pulley Co.*

581. Spring Steels

Spring steel catalog offers 785 hardened and tempered spring ste 133 cold rolled and bright anneal in stock. *Sandvik Steel*

582. Stainless Applicatio

Bulletin on advantages of stai the chemical industry; units made cation, design, alloys. *Crucible St*

583. Stainless Bars

28-page technical book on stainl bars includes processing info about cutting, welding, forging, u machining, and heat treating. *Al Ludlum*

584. Stainless Castings

Slide chart gives chemical comp mechanical properties, heat tre ASTM, SAE and AISI designati each alloy. *Lebanon Steel Found*

585. Stainless Pipe

Bulletin gives methods of bend joining stainless pipe. Dimensio weights of various types. *Babcock cox*

FIRST
PERMIT
(Sec. 34
Cleve

BUSINESS REPLY CARD

No Postage Stamp Necessary If Mailed In the United States

4c POSTAGE WILL BE PAID BY—

METAL PROGRESS

7301 Euclid Avenue

CLEVELAND 3, OHIO

chines themselves.

lling sodium in the Application to de-

on ultrasonic flux- al coating—process *rojects, Inc.*

ting
uide features spark lard tool and die

ph
ribes large Littrow quartz spectograph spectrum analysis.

ter
mass spectrometer sis. Instrument, its *Consolidated En-*

try
m quality control spectrometer. *Baird*

ntrol
e speed drives and *Pulley Co.*

eels
offers 785 sizes of d spring steels, and right annealed sizes el

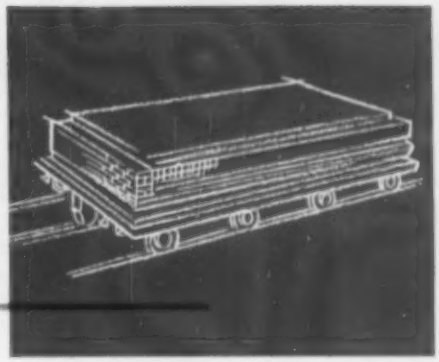
Applications
ages of stainless in units made, fabri- *Crucible Steel*

Bars
ok on stainless steel essing information , forging, upsetting, treating. *Allegheny*

Castings
emical composition, s, heat treatment, SI designations for *Steel Foundry*

Pipe
ods of bending and e. Dimensions and pes. *Babcock & Wil-*

HOLCROFT and the CAR-TYPE FURNACE



Car-type furnaces solve the problem of heat treating large, awkward-to-handle stock—or large quantities of parts which together form a bulky, heavy load.

Furnaces of this type can be either batch or continuous. In the first case, the load is rolled into the furnace and left there until the heat treat cycle is completed. When several cars are placed in line—the last one added pushing the row of cars through the furnace zones—the operation is continuous.

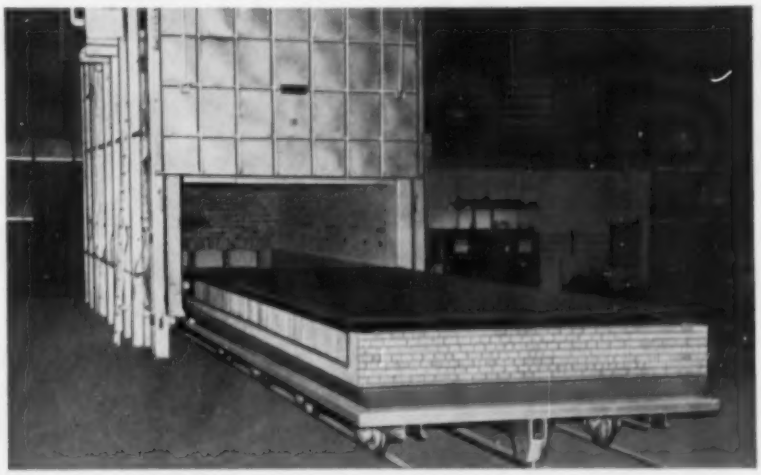
This is just one major classification of stock handling. Actually, there are several others—each to be considered when selecting a furnace to do a job. This is the type of flexibility you find when you turn your heat treat problems over to Holcroft. Only here do you get the personalized attention—the custom engineering—that slashes your costs and makes possible new standards in quality control.

Holcroft's new book "Blazing the Heat Treat Trail" is jam-packed with the various factors governing the selection of a heat treat furnace. But, see for yourself—write for your copy —today! Holcroft & Company, 6545 Epworth Blvd., Detroit 10, Mich.

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

CHICAGO, ILL. CLEVELAND, OHIO HOUSTON, TEXAS PHILADELPHIA, PA.

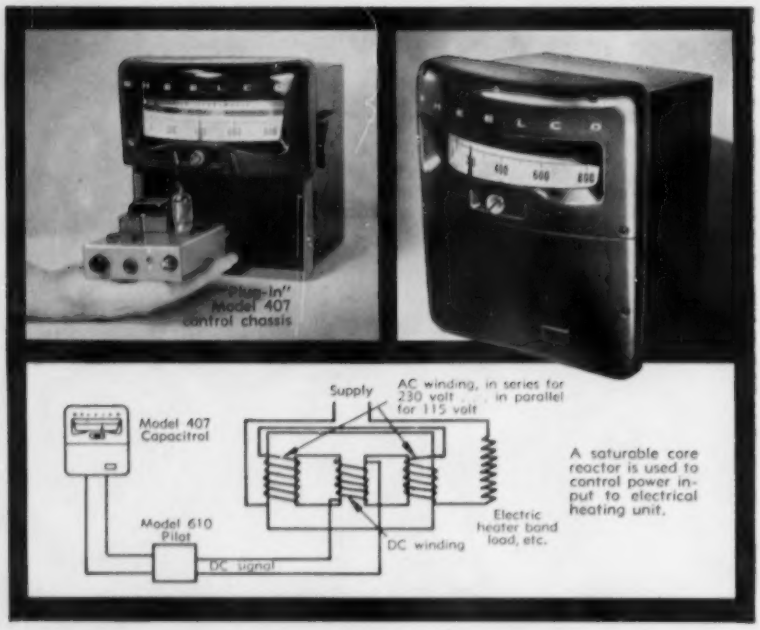
CANADA: Walker Metal Products, Ltd., Windsor, Ontario EUROPE: S.O.F.I.M. Paris 8, France



FIRST CLASS
PERMIT No. 1595
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

BARBER COLMAN

NEW Wheelco Model 407 Capacitrol


"Plug-In" Model 407 control chassis
Model 407 Capacitrol
Supply
AC winding, in series for 230 volt ... in parallel for 115 volt
Model 610 Pilot
DC signal
DC winding
Electric heater band load, etc.
A saturable core reactor is used to control power input to electrical heating unit.

Introduces saturable-core reactor control for "stepless" proportioning!

Wheelco's done it again! For electric furnaces, ovens, and kilns — a *totally new* control form that gives you "stepless" proportioning. A saturable core reactor controls power input to the electrical heating unit . . . output is varied through an infinite number of power levels from a maximum of 90% of rated capacity to a minimum of 3%, depending on demands of the sensing elements. It's a *totally new* instrument, too . . . with leading features you rarely expect, *or get*, in a low-cost temperature controller.

"Describes six control forms available"

Write or ask your Wheelco representative for Bulletin F6314-1 describing six "plug-in" control forms available in the new "400 Series."

WHEELCO INSTRUMENTS DIVISION

BARBER-COLMAN COMPANY, DEPT. N, 1518 ROCK STREET, ROCKFORD, ILL.
BARBER-COLMAN OF CANADA, LTD., DEPT. N, TORONTO, ONTARIO, CANADA

Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

586. Stainless
Selector gives ma
and mechanical pro
sistance of various
steel. *Crucible Steel*

587. Stainless
36-page bulletin o
of processing at di
International Nickel

588. Stainless
Bulletin shows pl
tank heads, flanges.

589. Stamping
New 12-page catalo
ing, forming and he
wood Mfg.

590. Stamping
Data on how stan
time and money. *J.*

591. Steel
Bulletin on nickel
alloy, high-strength
Sheet and Tube

592. Steel 52
Data sheet on hi
made by vacuum me

593. Steel Tu
48-page Handbook
and forging steel tu
ing, cutting and jo
scribed. *Ohio Seaml*

594. Stiffness
Data on stiffness
six ranges. *Taber*

595. Stress-St
New 28-page bul
standard recorders
strain followers, for
ing machines. *Bald*

596. Subzero
Catalog gives comp
subzero metal treat
Zero Products

597. Tellurium
6-page pamphlet
tellurium copper all

598. Tempera
Bulletin on temp
system to signal ex
temperature at one
mo Electric Co.

599. Tempilst
"Basic Guide to F

309	334	359	38
310	335	360	385
311	336	361	386
312	337	362	387
313	338	363	388
314	339	364	389
315	340	365	390
316	341	366	391
317	342	367	392
318	343	368	393
319	344	369	394
320	345	370	395
321	346	371	396
322	347	372	397
323	348	373	398
324	349	374	399
325	350	375	400
326	351	376	401
327	352	377	402
328	353	378	403
329	354	379	404
330	355	380	405
331	356	381	406
332	357	382	407
333	358	383	408

Stainless Steel
r gives machinability, physical hanical properties, corrosion re- of various grades of stainless *rucible Steel*

Stainless Steel
e bulletin on effect on properties ssing at different temperatures. *onal Nickel*

Stainless Steel
n shows plates, forgings, sheets, ds, flanges. *G. O. Carlson*

Stamping
-page catalog on stamping, draw- ning and heading. *Plume & At- g.*

Stampings
n how stamped assemblies save l money. *J. H. Sessions*

Steel
n on nickel-copper steel of low- igh-strength type. *Youngstown d Tube*

Steel 52100
sheet on high-purity 52100 steel, vacuum melting. *Vacuum Metals*

Steel Tubing
e Handbook F-3 on fabricating ging steel tubing. Bending, shap- ting and joining operations de- *Ohio Seamless Tube*

Stiffness Testing
on stiffness tester which tests in ges. *Taber Instrument Corp.*

Stress-Strain Recorders
28-page bulletin No. 4215 on 16 l recorders and 50 models of llowers, for use on standard test- chines. *Baldwin-Lima-Hamilton*

Subzero Treatment
g gives complete technical data on metal treatment. *Cincinnati Sub- oducts*

Tellurium Copper
e pamphlet on properties of 0.5% n copper alloy. *Chase Brass*

Temperature Control
tin on temperature-monitoring to signal existence of dangerous ture at one or more points. *Ther- tric Co.*

Tempilstiks
e Guide to Ferrous Metallurgy," a plastic laminated wall chart in color. *Claud S. Gordon*

600. Test Bars
New 18-page bulletin No. 168 on design of test bar pattern, production of test bars, testing procedures. *Federated Metals Div., American Smelting and Refining Co.*

601. Test Cabinets
New 6-page catalog on environmental testing equipment—temperature, humidity, sand and dust, explosion, rain and sunshine, altitude. *American Research*

602. Textured Stainless
Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

603. Thermocouple
Data sheet on immersion thermocouple for measuring bath temperatures. Operation, wiring, equipment. *Leeds & Northrup*

604. Thickness Testers
6-page catalog on Audigage thickness testers. Characteristics and applications of five models. *Branson Instruments*

605. Timer
Folder on timer for controlling on-off cycling of two independently adjusted load circuits in machine and process control. *Automatic Temperature Control*

606. Titanium Tubing
Bulletin No. 42 on properties, applications and advantages of titanium tubing. *Superior Tube Co.*

607. Tool & Die Steels
28-page guide to qualities and sizes available. *Uddeholm*

608. Tool Steel
Folder on high carbon, high vanadium tungsten base high speed steel. *Latrobe*

609. Tool Steel
Data sheets on high speed, hot work, air, oil and water hardening tool steels, alloy steels, machinery steels, stainless steels, welding rods. *Crucible Steel*

610. Tool Steel Color Guide
Color guide to estimate temperatures has heat colors on one side and temper colors on the other. *Bethlehem Steel*

611. Tubing
28-page book on stainless and alloy tubing shows types available, properties, weight tables, corrosion data. *Trent Tubes*

612. Tubing Steels
Chart of carbon, alloy and stainless tubing steels for high temperature and high pressure service. *Babcock & Wilcox*

613. Tungsten
New 20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. *Sylvania Electric Products*

614. Tungsten Alloy
Data sheet on machinability and other properties of high tungsten alloy produced by powder metallurgy. *Carboloy Dept.*

615. Vacuum-Melted Metals
Data on alloys available and their physical properties. *Carboloy Dept., General Electric Co.*

616. Vacuum Metallizing
Reprint "High Vacuum Metallizing of Metals and Plastics." *Consolidated Vacuum Corp.*

617. Vacuum Pumps
New Bulletin 400 on high-vacuum pumps. *Kinney Mfg.*

618. Vanadium Products
12-page brochure on 25 steel, iron, aluminum and chemical products. Composition and applications. *Vanadium Corp.*

619. Ultra Strength Steel
Results of three year research and test program evaluating properties of Type 4340 steel for aircraft structures. *International Nickel*

620. Ultrasonic Cleaning
Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

621. Welding
New 52-page catalog on gases, welding and cutting equipment and accessories for job shops, maintenance departments and other users of light, gas and arc equipment. *Air Reduction Sales*

622. Welding
10-page bulletin on welding technique involving use of weld insert. *Arcos*

623. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

624. X-Ray Diffraction
Bulletin 8A-3505 on film or direct recording X-ray diffraction apparatus. *X-Ray Div., General Electric*

625. X-Ray Supplies
50-page catalog of industrial X-ray supplies and accessories. *Westinghouse*

February, 1955

359	384	409	434	459	484	509	534	559	584	609
360	385	410	435	460	485	510	535	560	585	610
361	386	411	436	461	486	511	536	561	586	611
362	387	412	437	462	487	512	537	562	587	612
363	388	413	438	463	488	513	538	563	588	613
364	389	414	439	464	489	514	539	564	589	614
365	390	415	440	465	490	515	540	565	590	615
366	391	416	441	466	491	516	541	566	591	616
367	392	417	442	467	492	517	542	567	592	617
368	393	418	443	468	493	518	543	568	593	618
369	394	419	444	469	494	519	544	569	594	619
370	395	420	445	470	495	520	545	570	595	620
371	396	421	446	471	496	521	546	571	596	621
372	397	422	447	472	497	522	547	572	597	622
373	398	423	448	473	498	523	548	573	598	623
374	399	424	449	474	499	524	549	574	599	624
375	400	425	450	475	500	525	550	575	600	625
376	401	426	451	476	501	526	551	576	601	
377	402	427	452	477	502	527	552	577	602	
378	403	428	453	478	503	528	553	578	603	
379	404	429	454	479	504	529	554	579	604	
380	405	430	455	480	505	530	555	580	605	
381	406	431	456	481	506	531	556	581	606	
382	407	432	457	482	507	532	557	582	607	
383	408	433	458	483	508	533	558	583	608	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name _____

Title _____

Company _____

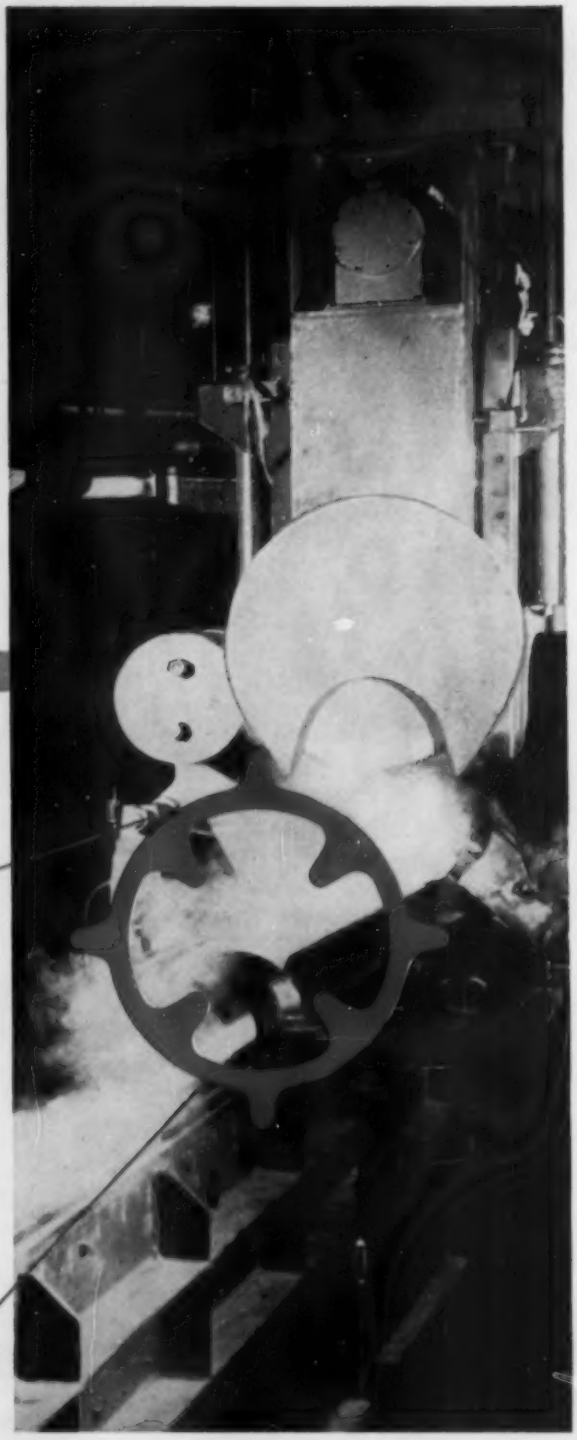
Address _____

City and State _____

Postcard must be mailed prior to May 1, 1955
Students should write direct to manufacturers.

let us take a closer look at your

"difficult to solve" problems involving tubing and solids of special alloys and cross-sections



Three years of experimental production and several thousand tons of finished extruded products have given B&W a background that can be put to work for you in solving problems involving tubing and solids of special alloys and cross-sections. Through extrusion at B&W:

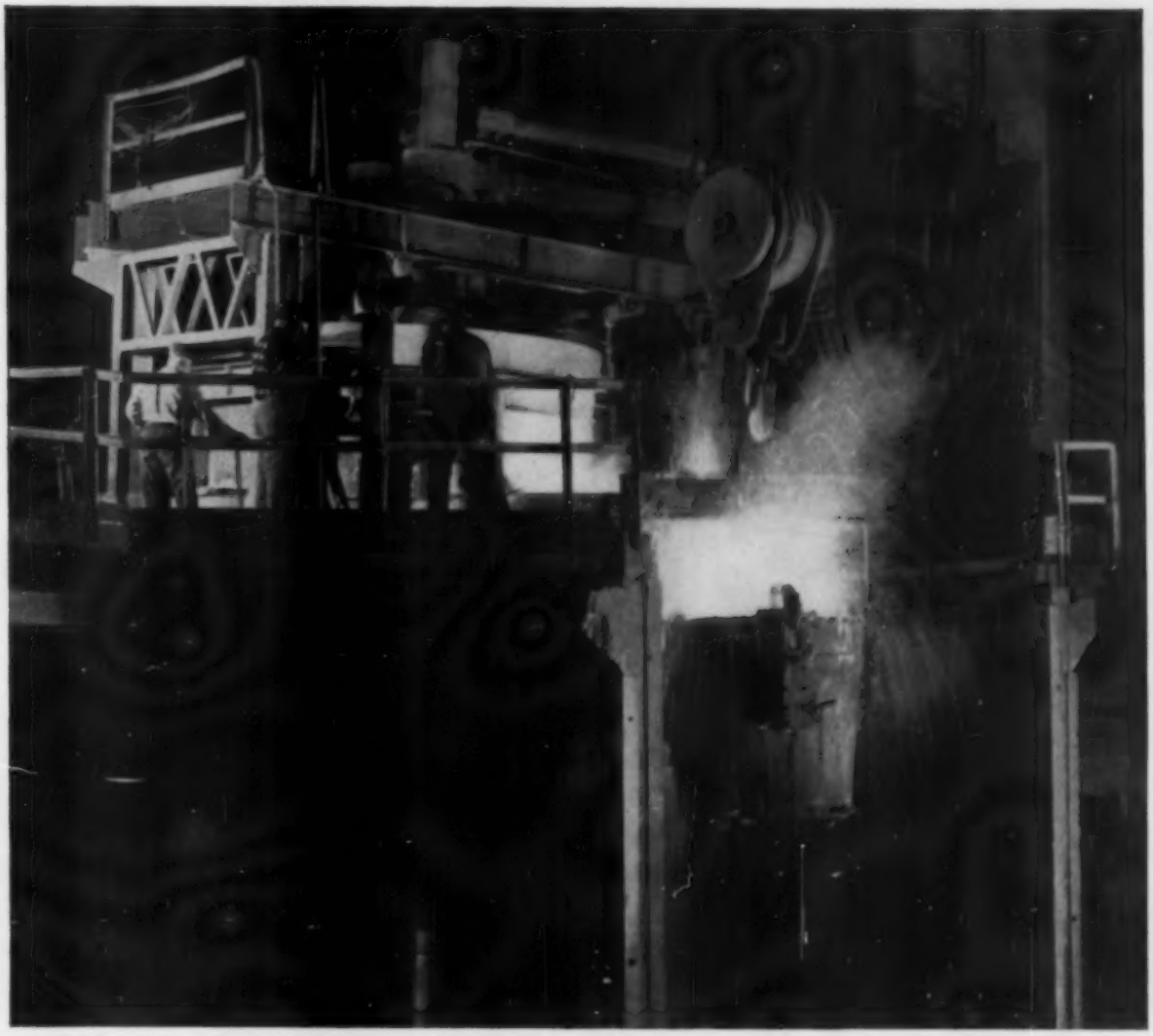
1. **New alloys have become commercially available as seamless tubing.** These include certain proprietary alloys and various types of ferrous alloys which have been known previously as non-pierceable materials.
2. **Tubing having certain special shaped cross-sections has been produced commercially.** This includes tubing having inside and outside shapes which are independent of each other, such as circular OD-finned ID, used to solve special heat transfer problems.
3. **Solids having special shaped cross-sections have been produced.** These include shapes difficult or impossible to produce as rolled sections.

Through extrusion, Mr. Tubes, your local B&W Tubing Representative, has helped others to solve problems involving tubing and solids of special materials and cross-sections. Call on him if you have such problems; chances are he will be able to help you.

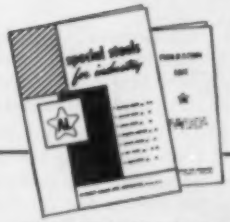
THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-4032(X)



Can we pour a "cup" for you?



WRITE TODAY

For These Publications

1. SPECIAL STEELS FOR INDUSTRY . . . 16 pages of essential data on the proper selection and application of principal AL special alloy products: stainless, tool and electrical steels and sintered carbides.

2. PUBLICATION LIST . . . a complete listing of all AL publications, both technical and non-technical (over 100 in all), with a handy order form for your convenience.

ADDRESS DEPT. MP-62

Somewhere in your setup, there's a spot where one of our special alloy steel products (stainless or heat-resistant, tool or electrical) can be used to gain you a real advantage. *Right now!* It might come from reduced production, maintenance or depreciation costs. Or it might come from increased sales appeal: gaining an edge on competition in beauty, strength, service life or performance. The advantage is *there*—and our Research and Engineering Staffs are ready to help you find it. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

PIONEERING on the Horizons of Steel

Allegheny Ludlum

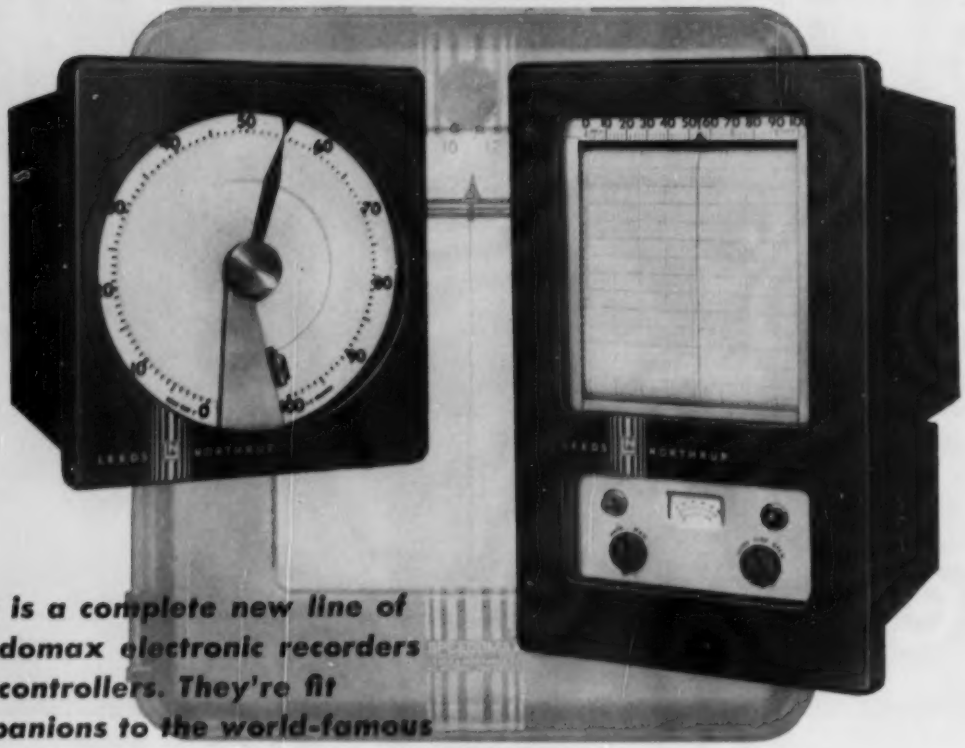
WSD 5144-B

Stocks of Allegheny Stainless carried by all Ryerson Steel warehouses

AL®
LEADING PRODUCER HIGH-ALLOY STEELS

New, compact

Speedomax® Instruments can modernize process control in hundreds of plants!



Here is a complete new line of Speedomax electronic recorders and controllers. They're fit companions to the world-famous Speedomax Type G. They are called Type H.

These new instruments can help the operation of a tremendous variety of industrial processes—including many which are perhaps now under-instrumented. And L&N's new production techniques bring Speedomax H equipments within reach of processes which couldn't formerly justify high-quality electronic potentiometers.

Especially significant to operators who now employ filled-system and deflection instruments are the benefits of electronic potentiometer performance. For instance, you can install Speedomax wherever you wish, without a thought for the distance to its sensing element. And Speedomax won't "drift" in accuracy as it ages—it stays on the job and holds the process on spec. If you damage either the sensing element or lead, you simply repair or replace on the job. Speedomax never goes back to the factory for re-calibration, so you do not need spares—thus you save both inventory and storage space.

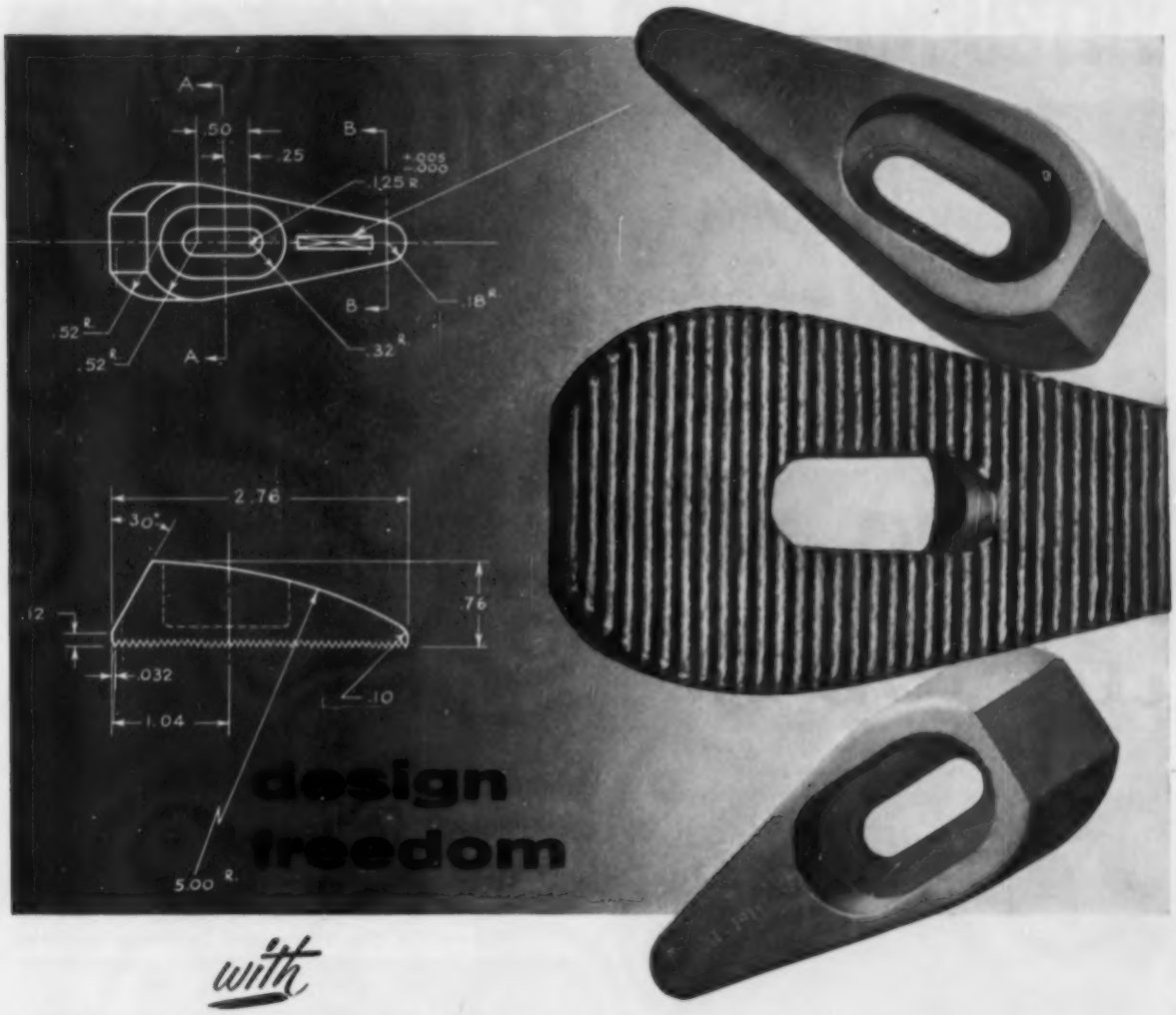
Anyone familiar with L&N construction will see it again in Type H. The same husky components, anti-friction bearings, rigid assembly and ultra-accessability.

New features include a "fill-in-place" pen; a new, ingenious on-off control switch; more plug-in components. External leads go to a terminal board on outside back of case, for easy installation and maintenance.

One of the round-chart instrument's special features is its long scale; this is used both in setting the control point and for reading temperature. All instruments have especially easy, accurate means for moving the control point setter.

You can choose any type of control action—On-off; Proportional Action; Proportional with rate and reset actions. Any L&N office can supply details and application engineering assistance; or write us at 4927 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP
instruments *automatic controls* • *furnaces*



with

CRUCIBLE ACCUMET PRECISION INVESTMENT CASTINGS...

Here's another good example of how Accumet Precision Investment Castings help put an end to design problems.

To machine the curved and tapered surfaces, elongated hole and counterbore, and serrations on this AISI 4140 alloy steel aircraft part, would have been too costly to be practical. But the parts were quickly and economically produced by investment casting.

More and more parts are being *designed* specifically for the investment casting process. And there are good reasons why. Crucible Accumet Precision Castings allow the greatest freedom of design. Intricately shaped parts can be made of any grade of steel, including high-alloys, in large quantities and at low cost.

It will pay you to let your local Crucible representative give you the whole story of how Accumet Precision Castings can help you produce a better product at lower cost.

CRUCIBLE first name in special purpose steels

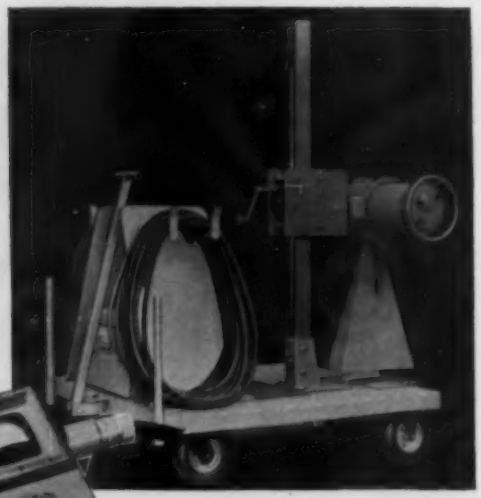
54 years of Fine *steelmaking*

ACCUMET PRECISION CASTINGS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

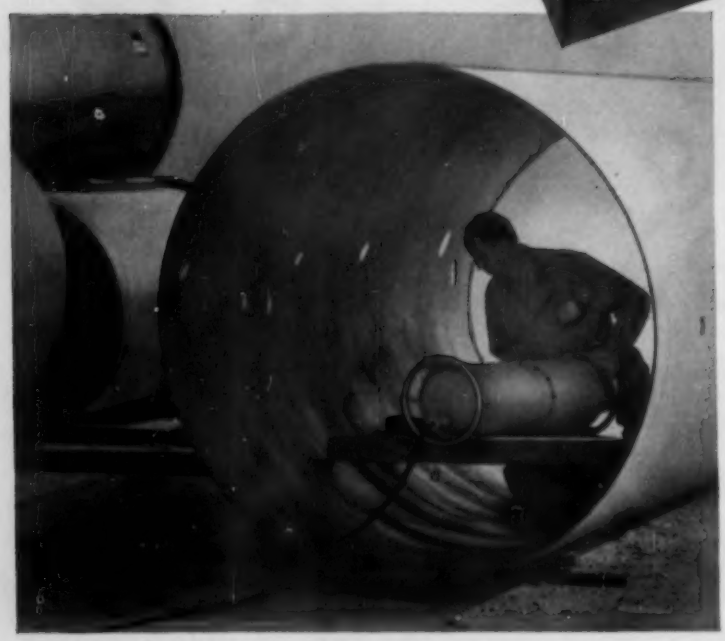
Compact, versatile x-ray inspection unit

goes where the job is



Here's one of the ten mounts available for OX-175. It's a mobile truck with elevating tube stand.

Sturdy control cabinet measures 18 x 18 x 14 inches . . . features large, easy-to-read dials, pinpoint accuracy of operation.



Shown here is inside-out x-ray inspection of a vessel weld.

General Electric OX-175 can help you cut costs . . . improve quality

Opening new horizons for industry in the use of x-ray inspection is General Electric's new OX-175. This rugged, lightweight apparatus handles the widest working range ever covered by a single x-ray unit.

The OX-175 can be easily moved from one job to the next, and its 200 feet of cable gives it extra portability. Highly versatile, the OX-175 can be equipped with angle-target tube for 60° field of radiation. With flat-target tube it will produce a 360° field of radiation that will radiograph an entire circumferential weld in one exposure. This also permits simultaneous radiographing of a large number of castings or assemblies by grouping these around the tube head.

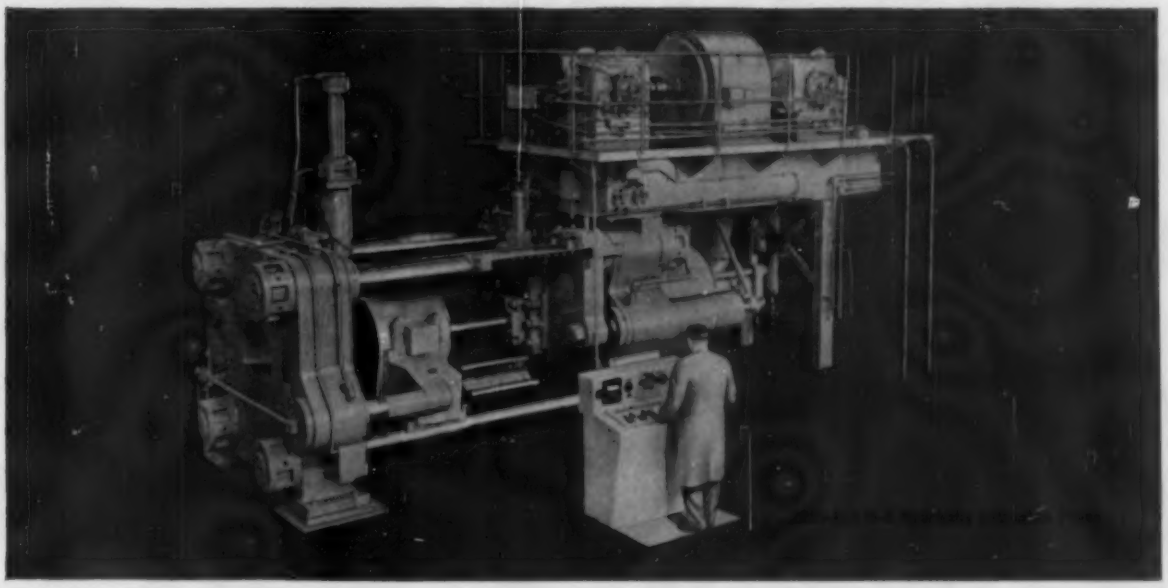
In addition, the small size of the tube head makes it ideal for inside-out radiography . . . giving greater radiographic coverage, better radiographs, and reducing protective needs.

Get all the facts from your G-E x-ray representative. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. AS-24.

Progress Is Our Most Important Product

GENERAL ELECTRIC

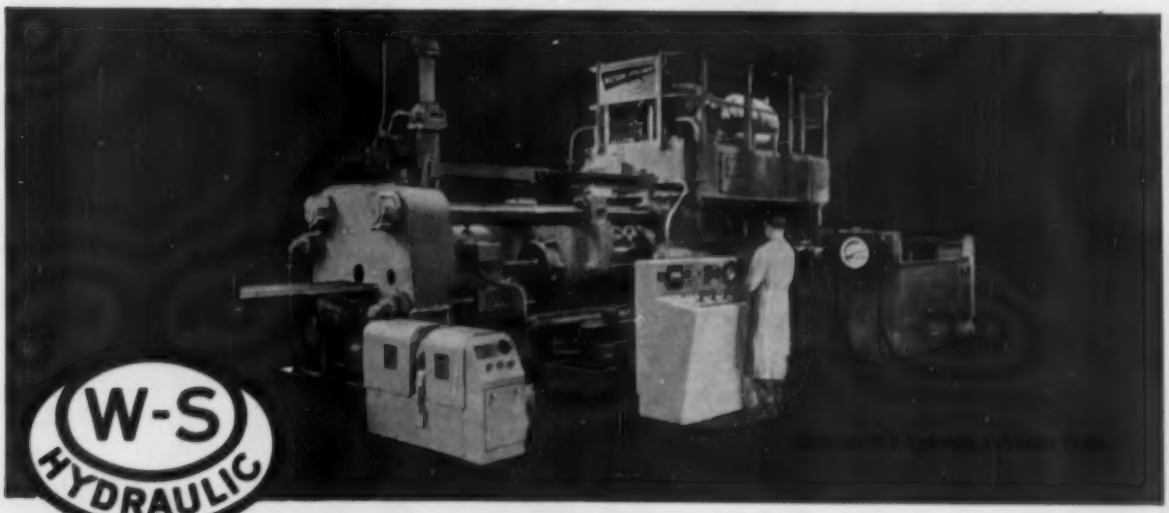
THE WORKHORSES OF THE INDUSTRY



When you buy a hydraulic extrusion press, you want to be sure of a press that stays on the job. You want to be sure, too, of the most advanced design for simplicity of operation and high production rates.

These are features that have made Watson-Stillman Hydraulic Extrusion Presses *the workhorses of the industry.* The "Completeline" of W-S Presses, conservatively rated at capacities from 500 to 5,000 tons, are designed for light metals, other non-ferrous metals, and steel.

Every step in the manufacture of these presses is conducted within the Watson-Stillman plant —design, engineering, pattern-making, machining, assembly, testing and shipment. That is why—for the soundest investment in extrusion presses—it pays to consult Watson-Stillman first.



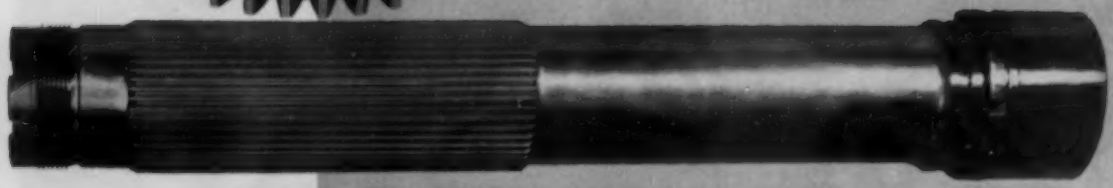
ESTABLISHED-1848

THE WATSON-STILLMAN COMPANY
DIVISION OF H. K. PORTER COMPANY, INC.
187 Aldene Rd., Roselle, New Jersey

A DIVISION OF HKP
H. K. PORTER COMPANY, INC.

Typical gear and spline processed by Wright Aeronautical Corp.

how much can you cut your finishing costs



with NITRALLOY®
and FLOE PROCESS NITRIDING

You can reduce or completely eliminate grinding, lapping or superfinishing time and cost after hardening with the Floe Nitriding Process.* On gears and splines and similar parts, your savings may run as high as 70 cents, or even more, out of every dollar otherwise spent on these finishing operations.

This is made possible by three characteristics of the process:

1. A surface with a minimum of "white layer" which is ideal for service with no after grinding or lapping operations.
2. Low temperature hardening and
3. Elimination of quenching – both of which minimize distortion.

In most instances, the surface is ready for service.

In addition, the Floe Process applied to any Nitralloy or other alloy steel suitable for nitriding gives you these other important advantages:

- superior case structure
- high wear resistance
- high fatigue resistance
- retention of hardness at high temperatures
- excellent core properties

PRODUCERS AND DISTRIBUTORS

Custom heat treaters and users of nitriding steels may obtain licenses for this process without limitation as to the source of supply.

Purchasers of Nitralloy steels from any of these producers or distributors automatically acquire the license to use the Process in converting the steels so purchased.

Joseph T. Ryerson & Son., Inc., Chicago, Milwaukee, St. Louis, Detroit, Cincinnati, Cleveland, Pittsburgh, Philadelphia, Charlotte (N.C.), Buffalo, New York, Boston, San Francisco, Los Angeles, Spokane, Seattle.

The Earle M. Jorgensen Co., Los Angeles, Oakland, Houston, Dallas, Tulsa.

Bowsteel Distributors, Inc., Linden, N. J.

Atlas Steels Limited, Welland, Ont.

Copperweld Steel Company, Warren, Ohio

Firth-Sterling Steel Co., McKeesport, Pa. (Nitrard steel only)

Rotary Electric Steel Co., Detroit, Mich.

Grede Foundries, Inc., Milwaukee, Wis.

Electric Steel Foundry Co., Portland, Ore.

This New Treatise will show you how the Floe Process can cut your finishing costs. Send for your copy.

*Patent No. 2,437,249

THE NITRALLOY CORPORATION • 230 PARK AVE., NEW YORK 17, N. Y.

COLD-ROLL FORMING

Yoder Cold Roll Forming Machine with Shear Type Automatic Cut-Off and Small Slitting Line installed by Wolverine Mouldings, Inc., Lincoln Park, Mich.

for the Growing Business

● As your business grows, new opportunities arise for drastic cost reduction through the use of cold roll formed parts or finished products.

Decorative metal mouldings is only one of a great many things you can make with a Yoder cold-roll forming machine.

For instance, you can economically make structural angles, channels, etc., up to ½ in. thick. You can form wide sheets or panels into cabinets or shells for refrigerators, ironers, lockers, radio and TV sets, etc. You can make virtually all the components for metal buildings, including trusses, joists, studs, siding, roofing, windows, and doors.

Edges of shapes can be folded in and over to make interlocking joints for cabinets, rolling doors, box and tubular products.

You can, in addition to longitudinal forming, do perforating, notching, embossing, coiling, curving, welding, etc. Sections can be cut to length and ends given almost any shape, plain or fancy, by means of one or two Yoder automatic cut-off machines synchronized with the forming speed.

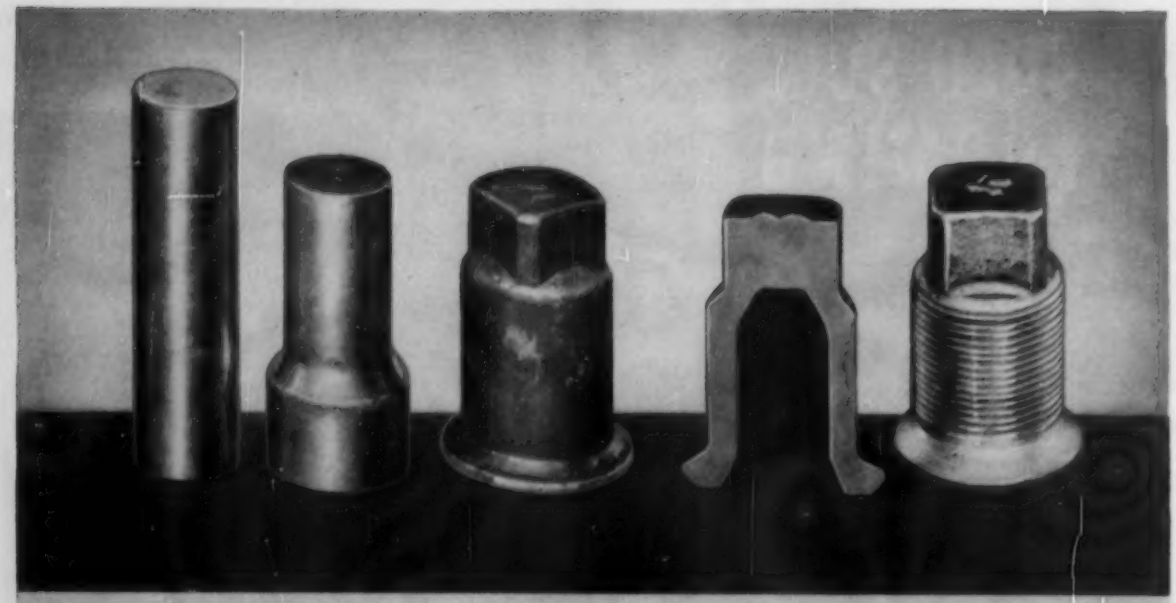
The Yoder Book on Cold-Roll Forming is an illustrated treatise on the art, the machines and many of the things they can do to reduce cost and increase production. A copy is yours for the asking. Consultations and estimates without cost or obligation.

THE YODER COMPANY • 5595 Walworth Ave., Cleveland 2, Ohio

Complete Production Lines

★ COLD-ROLL-FORMING and auxiliary machinery
★ GANG SLITTING LINES for Coils and Sheets
★ PIPE and TUBE MILLS — cold forming and welding

ENGINEERING YODER MANUFACTURING



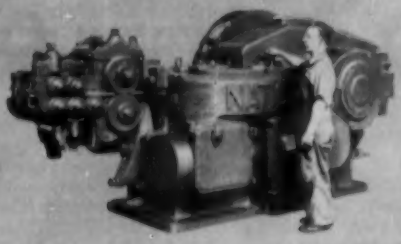
Budd WHEEL NUTS FORGED BY THE MILLION!

This is how the Budd Co.'s progressive Detroit plant has been forging truck wheel nuts by the million, day in and day out, for the past seven years.

In the sequence above, the forging blank is automatically cold headed from coiled hot rolled stock in a National 3/4-inch Double Stroke Solid Die Cold Header. After heating, blanks are forged in a High Speed Forging MAXIPRES of 300 tons capacity.

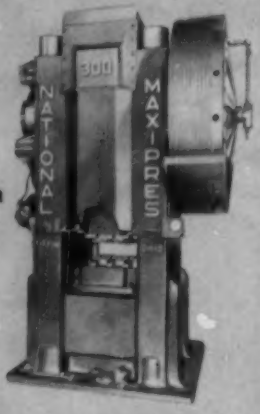
This is one of the first combinations of cold heading and hot forging. Budd has amassed an enviable record of production and material saved by the above method.

If you need to make metal parts faster, stronger and at lower cost, let us work with you. Send us your prints and samples, or better yet, visit us. No obligation.



NATIONAL ¾ in. Cold Header

NATIONAL 300 Ton MAXIPRES



NATIONAL MACHINERY COMPANY

TIFFIN, OHIO—SINCE 1874

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

Hartford Detroit Chicago

Cleaning Specialists*

*[SPE'CIAL·IST—One who devotes himself to some special branch of activity.]

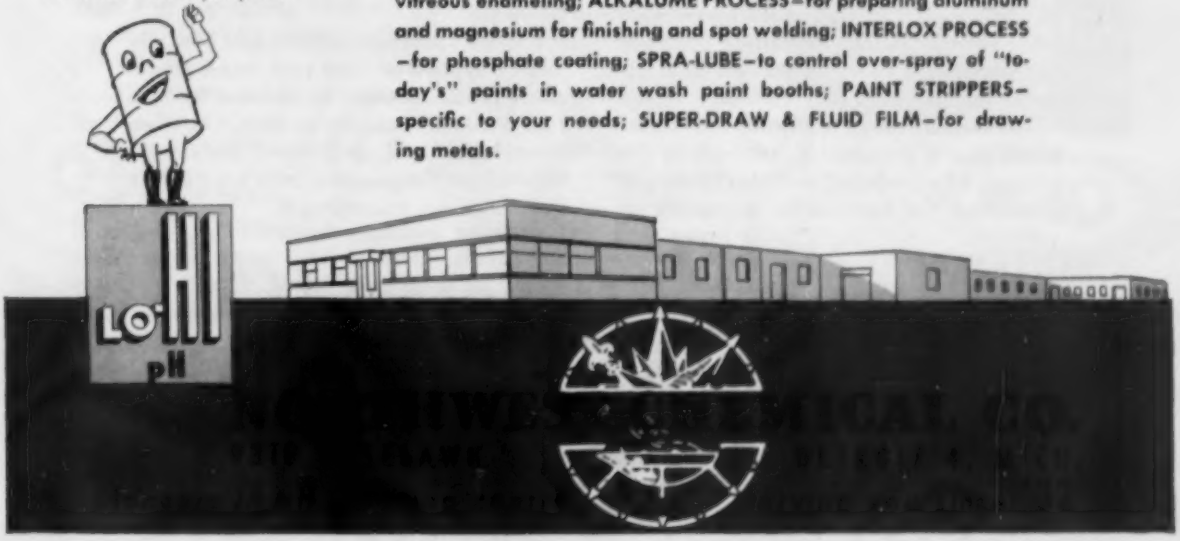
At Northwest our "special branch of activity" is solving your cleaning problems.

Behind your friendly, competent Northwest Sales Engineer stands a reputation for providing industry with low-cost, analytically-correct, job-adjusted chemical cleaners.

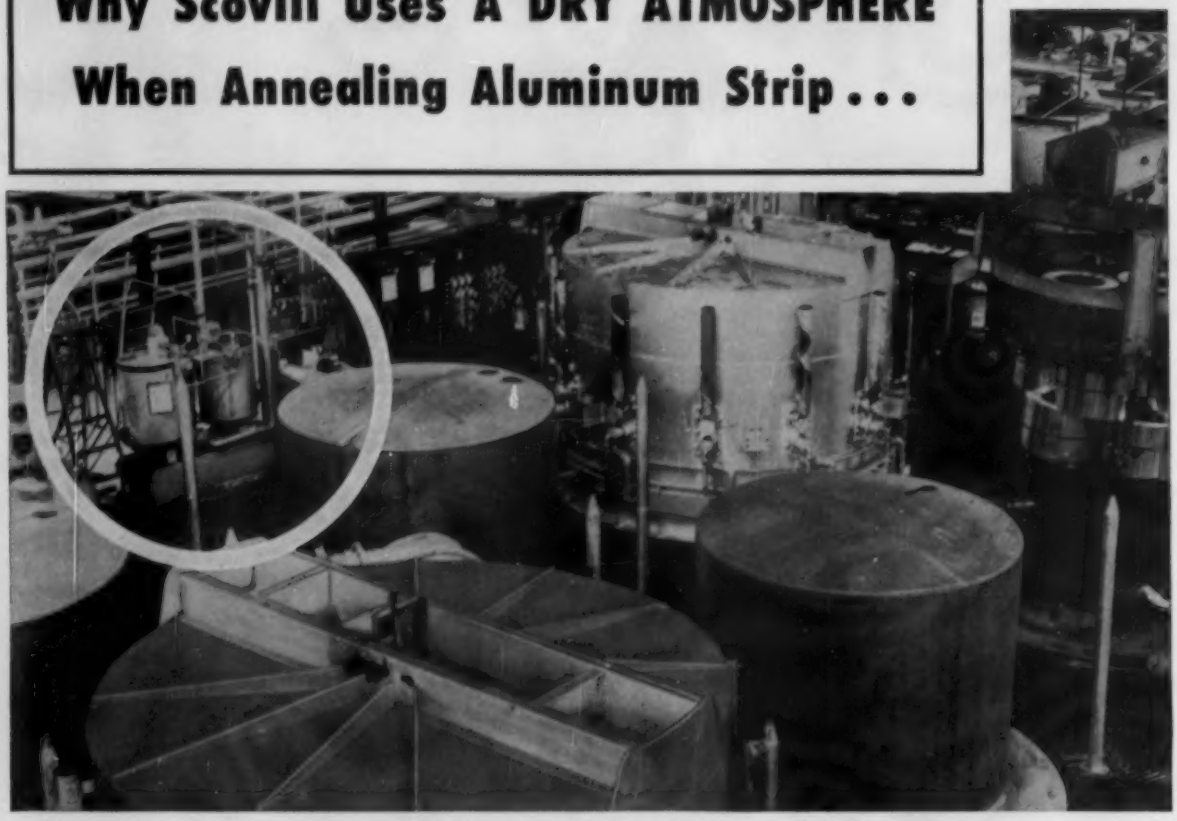
From Northwest's years of experience in formulating the RIGHT cleaner for your specific needs have come such developments as the LO-HI pH PROCESS—for cleaning prior to plating, painting, or vitreous enameling; ALKALUME PROCESS—for preparing aluminum and magnesium for finishing and spot welding; INTERLOX PROCESS—for phosphate coating; SPRA-LUBE—to control over-spray of "today's" paints in water wash paint booths; PAINT STRIPPERS—specific to your needs; SUPER-DRAW & FLUID FILM—for drawing metals.

Remember—YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER.

Northwest's production-tested chemicals and "Right the first time" recommendations will save you money. Northwest Service is as close as your phone.



Why Scovill Uses A DRY ATMOSPHERE When Annealing Aluminum Strip . . .



Lee Wilson bell-type annealing furnaces are used by the Scovill Manufacturing Co., Waterbury, Connecticut, for heat-treating aluminum strip. The Lectrodryer (circled) assures a *DRY protective atmosphere* for the process.

It helps give aluminum working properties similar to brass and some types of steel

Scovill finds that annealing in a dry atmosphere minimizes formation of abrasive scale caused by oxides, thus permitting generally no special new tools or changes in fabricating techniques.

To obtain a *really DRY* protective atmosphere, Scovill processes all atmosphere gas through a Lectrodryer* installed at the gas generator. The Lectrodryer is capable of reducing dewpoints far below the level where vaporous moisture is a problem. In some cases, Lectrodryers are drying air and gases to dewpoints as low as −100° F. These machines can handle pressures to 6,000 psi.

Inquire about Lectrodryers and how they may be applied to solve your moist atmosphere problem. Write for *Because Moisture Isn't Pink*, a booklet describing how industry is using Lectrodryers. Pittsburgh Lectrodryer Corporation, 317 32nd Street, Pittsburgh 30, Pennsylvania.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U.S. PAT. OFF.

Judge for yourself the advantages of

VANCORAM FERROVANADIUM

packed in bags

Look for the blue product marking which is the identifying color for Vanadium in Vancoram's original color coding system.

Each of these bags contains 25 lbs. of vanadium for handy cost-saving additions to furnace, cupola or ladle.

SAVES TIME AND MONEY—You don't have to weigh prior to alloy addition. Each bag contains exactly 25 lbs. of vanadium. Thus you save on handling costs.

CONTAMINATION AND WASTE ELIMINATED—The ferrovanadium is confined to its own bag . . . made of strong, white, cotton fabric with a crepe-paper interlining that's adhered to the outer covering with a special moisture-resisting adhesive. Bags eliminate waste common to other types of packing.

INVENTORY AND HANDLING PROBLEMS SIMPLIFIED—Standard weight of each bag means quicker inventory. Palletized shipments can be handled quickly and easily by fork truck or crane. Each bag is clearly labeled for ready identification.

UNIFORMLY HIGH-GRADE MATERIAL—Vancoram ferrovanadium is produced under strictest quality control and thus is guaranteed to be physically clean and of uniform high quality.

Bagged ferrovanadium is another example of the way VCA works to help steelmakers make better metals faster—and at lower cost. Contact your VANADIUM CORPORATION representative for further information on Vancoram ferro alloys.

VANADIUM CORPORATION OF AMERICA

420 Lexington Avenue, New York 17, N. Y.

Detroit · Chicago · Pittsburgh · Cleveland

VANCORAM

Producers of alloys, metals and chemicals

looking for

fast... low-cost *degreasing?*

Try **ALL-PURPOSE** Nialk® **TRICHLOR**ethylene

Here's an ideal organic solvent for removing practically every kind of foreign matter from metal parts. Whether it's waxes, oils, greases, tars or metal chips, you'll find that Nialk TRICHLORethylene does the job safely, thoroughly and economically, leaving parts clean, warm and dry, ready for immediate assembly, inspection or surface treatment.

Nialk TRICHLORethylene is quick acting . . . it cleans and dries rapidly. Its low boiling range (86.6–87.8°C, based on standard ASTM tests) permits vaporization at low steam pressure. (And that narrow boiling range reflects its high purity.)

Cuts power consumption . . . Nialk TRICHLORethylene can be heated by gas, steam or electricity. Its specific heat is less than ¼ that of water. You'll get concentrated vapor at only 188°F.

Nialk TRICHLORethylene is thorough . . . its low viscosity (0.58 centipoises at 20°C) and low surface tension (about 29 dynes per cm at 30°C) give rapid wetting of surfaces, plus thorough diffusion into pores and relatively inaccessible openings.

Cuts vapor loss . . . (its vapor density is 4.5 times that of air). It is completely re-usable after distillation, has no flash point, no fire point and is classed as nonflammable at room temperature and only moderately flammable at higher temperatures.

A request, written on your company letterhead, will bring you a free copy of our Nialk TRICHLORethylene booklet.

NIAGARA ALKALI COMPANY

60 East 42nd Street
New York 17, New York

NIALK Liquid Chlorine • NIALK Caustic Potash • NIALK Carbonate of Potash
NIALK Paradichlorobenzene • NIALK Caustic Soda • NIALK TRICHLORethylene
NIAGATHAL® (Tetrachloro Phthalic Anhydride)

MIDVALE "PUTS TEETH" IN MARINE DRIVE

This 159½" I. D. gear tire for the reduction gear in a high speed marine drive is receiving the rough machining at Midvale. From pour to machining it has been built for toughness . . . higher resistance to wear.

Toughness of forgings at Midvale is achieved by using only the finest part of the ingot originally poured. Experienced forgers shape it up for rugged service using a 6,500 ton hydraulic forging press. Heat treating cycles based on Midvale's long experience are thoroughly followed to produce the maximum in mechanical properties. Final machining is done on equipment capable of handling rough or finish machining on practically any size product.

At Midvale the final gear tire represents only a fraction of the original ingot—73,500 pound ingot was required to make this gear tire which was 15,640 pounds in the rough machined state when shipped. This is one of the reasons Midvale gear tires . . . rings . . . roll shells are noted for their long life. Why Midvale forgings, whether 300 or 300,000 pounds are tough for extra service life and never failing performance. For forgings that last see Midvale first.

THE MIDVALE COMPANY- Nicetown, Philadelphia 40, Pa.

Offices: New York, Chicago, Pittsburgh, Washington, Cleveland, San Francisco

MIDVALE

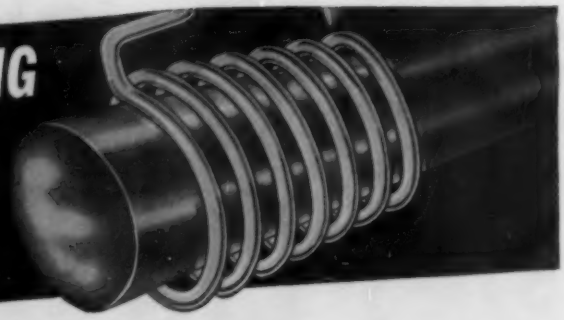
FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

YOU CAN HEAT ANYTHING

FROM A NEEDLE . . . TO

A TURBINE SHAFT

FASTER and BETTER



BRAZING

Permits widest choice of silver or copper brazing alloys from lowest to highest melting points. Ideal for brazing carbide tips.

HARDENING

Heat localized exactly where wanted at desired temperature. Ideal for gears, cams, bearing surfaces, cutting tools and other areas that are subject to wear.

SOLDERING

Speedily and neatly performs intricate soldering applications with or without the use of preformed rings.

ANNEALING

Ideal for annealing, stress-relieving, normalizing or preheating selected areas.

MELTING

Readily melts quantities of ferrous and non-ferrous metals in either graphite or ceramic crucibles.

WITH **LepeL**

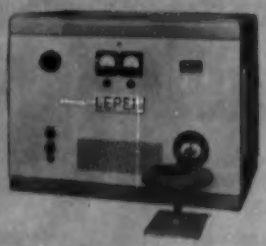
HIGH FREQUENCY

Induction

HEATING UNITS

The Lepel line of induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.



2½ KW INDUCTION HEATING UNIT

20 KW INDUCTION HEATING UNIT

100 KW INDUCTION HEATING UNIT

LEPEL Electronic Tube GENERATORS
1 KW; 2½ KW; 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters
2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information on high frequency induction heating.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

choose CRUCIBLE COLD ROLLED STEELS

for finer finish... better edges... closer tolerances

Crucible's *complete* quality-control during production of cold rolled alloy specialty strip steels means *extra* performance in your shop. And Crucible-patented production equipment makes possible cold rolled steels with finer finish, better edges, greater physical uniformity, and closer tolerances.

At Crucible, the country's leading producer of *special purpose steels*, you'll find a group of metallurgists experienced in cold rolled steels who are ready to help you develop your specification. You'll get the steels you choose fast, too, for Crucible cold rolled stocks are large... both in coils and cut lengths.

So come to Crucible for *all* your cold rolled steel needs. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pennsylvania.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

From Vacuum Melting—improved alloys with exceptional properties

. . . long SERVICE LIFE, for example

Vacuum-melted alloys greatly extend the service life of parts operating under severe conditions. High-temperature aircraft ball bearings, for example, last *three times* longer when made of vacuum-melted alloy steel. And jet engine turbine blades far outperform those of conventional air-melted alloys.

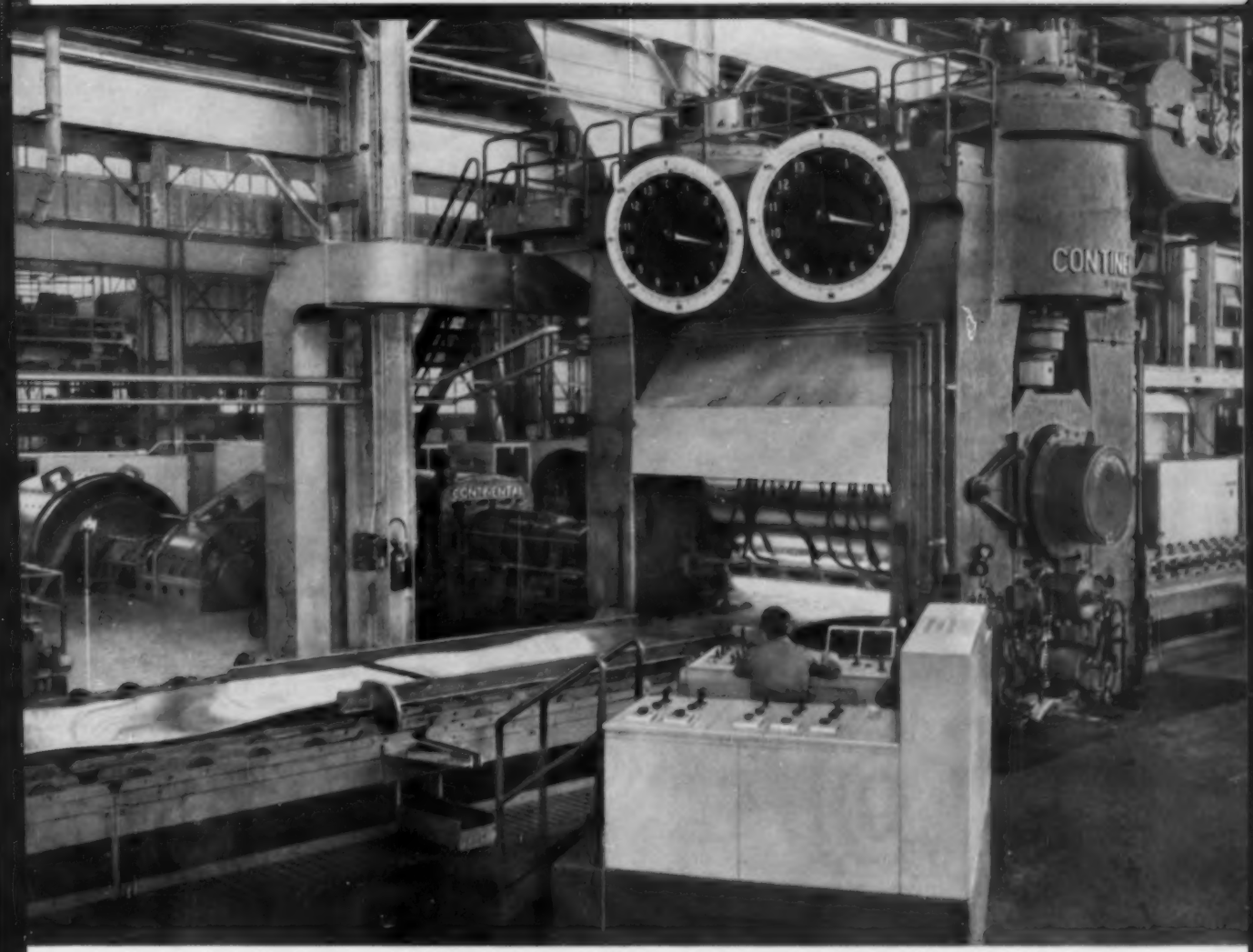
There's good reason for the exceptional properties of vacuum-melted metals. They are cleaner — free of inclusions which prevent conventional air-melted alloys from reaching optimum performance. For during high-vacuum melting gaseous impurities are literally sucked from the molten metal. Result: higher production yields . . . long service life of parts . . . improved fabrication characteristics.

Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted metals, now has them available in tool, high-speed, stainless and alloy steels — in most sizes and grades — as well as special ferrous and nonferrous alloys. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation



144-inch Four-High Tapered Plate Mill, Aluminum Company of America, Davenport, Iowa.

Now! A high-precision Plate Mill by Continental

This heavy-duty Continental 144-inch four-high plate mill built for Aluminum Company of America's Davenport, Iowa, Works produces a uniform, predetermined end-to-end taper in both sheet or plate aluminum alloy, as well as the full range of commercial plate. Both hot and cold rolling operations are performed on this mill. Gauges and tapers are maintained to the most exacting requirements. Continental produces—from preliminary engineering to satisfactory operation—varied types of ferrous and non-ferrous mills, with complete auxiliaries, for flat and shape rolling.

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division, Erie, Pa.

CHICAGO • PITTSBURGH

CONTINENTAL
Foundry & Machine
Company

Billet Peeling pays dividends!

Carbon, Alloy or Non-ferrous

This Continental-Medart billet conditioning process pays dividends in speedy operation and complete recovery of metal.

Billet peeling—as compared with scarfing or pickling—ends problems of air and river contamination . . . eliminates burning, and salvages all waste metal for remelting. The Continental-Medart method is the fastest billet peeling operation, ranging from 1 to 40 feet per minute throughput. The operation can be arranged for close surface control or deep, hogging cuts on diameters from 3″ to 33″.

Continental-Medart has built the largest Billet Peeler in existence and regularly produces a full size range. When your operations call for fast, accurate billet conditioning, call in your Continental-Medart representative.

Continental Building
220 Grant Street, Pittsburgh 19, Pa.

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division, Erie, Pa.

CONTINENTAL
Foundry & Machine
Company

Metal Progress

BULLETIN BOARD

THE BUYERS GUIDE FOR METALS ENGINEERS

Cut Costs With

FREE

Cutting Oil Chart

Use this free cutting oil chart as a handy guide to production costs and to more efficient machining operations.
Steel and nonferrous metals are charted with the proper cutting oil for many applications. Shows you how to use lubricants, sulphurized or compounded with extreme pressure additives, for all operations.

KELCO

ALDRIDGE INDUSTRIAL OILS, Inc.

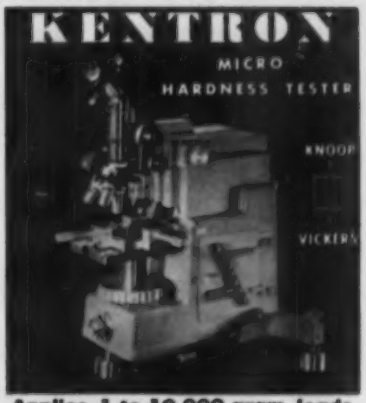
2401 W. 140th St., Cleveland 11, Ohio

LIST NO. 100 ON INFO-COUPON PAGE 61

If you want to perform Tensile or Brinell testing operations quickly and simply—*contact*

Detroit Testing Machine Company
9338 Grinnell Ave. • Detroit 13, Mich.

LIST NO. 54 ON INFO-COUPON PAGE 61



Applies 1 to 10,000 gram loads

Write for Bulletin

Kent Cliff Laboratories Div.
The Torsion Balance Company
CLIFTON NEW JERSEY

LIST NO. 53 ON INFO-COUPON PAGE 61

LAB-HYAM

Protective Atmosphere H_2N_2
Less Expensive-More Convenient
LAB size for LAB work

Protected bright annealing is now here for test and pilot runs of electric metals, stainless steels, copper or silver brazing; for sintering or reducing powder metals and for bright tempering of any ferrous or non-ferrous metal or alloy. How about atmosphere?

At 1900°F. from raw ammonia gas LAB-HYAM catalyst chamber produces a 75% hydrogen—25% nitrogen mixture from 99.9% dissociated ammonia, delivering protective atmosphere at 5 to 35 C.F.H. through needle valve.

Ask for Bulletin L-H for more information regarding this new laboratory size Dissociated Ammonia Generator.

LAB-HYAM H_2N_2 GENERATOR

AT LEFT, LABORATORY AND PILOT PLANT APPLICATIONS WITH CYLINDRICAL AND TUBE TYPE FURNACES.

BODER SCIENTIFIC COMPANY
719 LIBERTY AVE., PITTSBURGH 22, PA.
PHONE: ATLANTIC 1-5525

LIST NO. 55 ON INFO-COUPON PAGE 61

Inspection
Demagnetizing
or Sorting
PROBLEMS?
SOLVED with

MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 50 steel mills and fabricators are now using this equipment.

MAGNETIC ANALYSIS DEMAGNETIZERS

Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETIC ANALYSIS COMPARATORS AND METAL TESTERS

Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

MAGNETIC ANALYSIS MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

For Details Write: "THE TEST TELLS"
MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 51 INFO-COUPON PAGE 61

FOR *Ultra Sensitive*
STIFFNESS TESTING
it's the
TABER
STIFFNESS TESTER

New Taber V-5 Stiffness Tester is now available with 8 test ranges instead of 6. Now flexural rigidity of very thin materials such as metal foil can also be determined with SR 150-14 attachment. Recognized as the official test of initial and basic stiffness of sheet and wire, the V-5 has standardized test length, angle of deflection, and rate of loading to assure coordination between laboratories. Direct dial readings.

TABER ABRASER
Tests all metals for WEAR RESISTANCE under simulated conditions. Gives accurate numerical index for reports. Easy to use!

Write for Illustrated Literature
INSTRUMENT CORPORATION
SECTION 19
111 Goundry St.
N. Tonawanda, N. Y.

LIST NO. 109 ON INFO-COUPON PAGE 61

TECHNIC
Soluble Gold
For Industrial and Decorative Electroplating

TECHNIC INC.
Providence, Rhode Island, U.S.A.
JAckson 1-4200

LIST NO. 124 ON INFO-COUPON PAGE 61

For positive blackening of steel and iron parts . . .
USE SWIFT BLACK!
For efficient metal cleaning
USE SWIFT METAL CLEANING COMPOUNDS!
For certain rust prevention
USE SWIFT RUST PREVENTATIVES!
For heat treating
USE SWIFT SALT BATH!
For quenching
USE SWIFT QUENCHING OILS!

Send TODAY for descriptive literature and technical data sheets.

Swift
INDUSTRIAL CHEMICAL CO.
Canton Connecticut

LIST NO. 92 ON INFO-COUPON PAGE 61

ULTRASONICS

for rapid, accurate, non-destructive THICKNESS MEASUREMENTS from oneside and accelerated METAL CLEANING

VIDIGAGE Automatic Thickness Tester
Direct-Reading 21" Cathode-Ray Tube. Infinite Ranges 2:1, as selected, between 0.015" and 6" of steel or equivalent. Accuracy 0.1%—1.0% according to use.

AUDIGAGE® Portable Thickness Testers
Battery-Operated. Ranges 0.020"-4" and 0.060"-12" of steel or equivalent

SONOGEN Ultrasonic-Power Generator
for Metal Cleaning and other industrial uses.

BRANSON INSTRUMENTS, inc. electronics development production
439 FAIRFIELD AVE · STAMFORD · CONN.

Literature on Request

LIST NO. 81 ON INFO-COUPON PAGE 61

RUST-LICK
IN
AQUEOUS SYSTEMS
Grade "B"
FERROUS METAL PROCESSING
Eliminates . . .
Rust
Fire Hazards
Toxicity
Dermatitis
Degreasing
Write for free sample and brochure
Specify Grade "B"
PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS

LIST NO. 105 ON INFO-COUPON PAGE 61

CIRCO Metal Cleaning Equipment CUTS costs

SINCE 1923

CIRCO

EQUIPMENT COMPANY

122 Central Avenue, Clark (Rahway), N. J.
Offices and warehouses in principal cities

CIRCO VAPOR DEGREASERS—large or small—automatic or manual operation

CIRCO METAL PARTS WASHERS—custom engineered to suit your production needs

CIRCO-SONIC DEGREASERS — newest development—cleaning by *ultrasonic* vibration

CIRCO-SOLV (Trichlorethylene) and PER-SOLV (Perchlorethylene) — high purity, low-cost solvents

FREE! Write for 32-page CIRCO Degreasing Manual

LIST NO. 10 ON INFO-COUPON PAGE 61

WELDCO FABRICATED MONEL PICKLING EQUIPMENT

• Hairpin Hooks • Sheet Crates
• Steam Jets • Chain
• Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3721 OAKWOOD AVE. . . YOUNGSTOWN, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 61

BASKETS

for all industrial requirements

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage

of any size and shape — any ductile metal

by THE C. O.

WIRE PRODUCTS JELLIFF SINCE - 1880

JELLIFF MFG. CORP.

28 Pequot Road
Southport, Conn.

LIST NO. 91 ON INFO-COUPON PAGE 61

Du-Lite FINISHED

The Marlin Firearms Co., "Famous for Fine Guns since 1870", has long depended on Du-Lite black oxide for an attractive finish that will be dimensionally stable throughout the life of the gun.

The Du-Lite process provides intricate precision parts with a durable, rust-resistant black oxide finish. And since Du-Lite penetrates the metal, all crevices and knurls are protected without affecting dimensions or fit.

If your target is durable, attractive, economical finishing, you'll want to know more about Du-Lite black oxide.

Whatever your cleaning or finishing problem—**Depend on Du-Lite.**

Write for complete information.

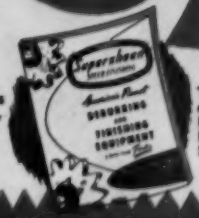
DU-LITE CHEMICAL CORP.
MIDDLETOWN, CONN.
Send more information on Du-Lite..... ☐
Send information on metal finishing products.. ☐
Have your representative call..... ☐
Name.....
Company.....
Address.....
City..... Zone.... State.....

Du-Lite
METAL FINISHING SPECIALISTS

LIST NO. 103 ON INFO-COUPON PAGE 61

HOW TO

Cut Finishing Costs up to 95%



52 Pages of Facts, Figures, Photos.

Tells the complete Barrel Finishing Story.

FREE

This amazing manual is guaranteed to open your eyes! Gives latest, up-to-the-minute facts on new developments in advanced barrel finishing equipment, compounds, abrasives. Shows how single unit installation replaces from 2 to 12 men. *Investigate. Send for* **FREE 52 PAGE CATALOG** *Write 917 Marshall Street*

ALMCO Supersheen

AMERICA'S LARGEST MANUFACTURER OF ADVANCED BARREL FINISHING EQUIPMENT—MATERIALS AND COMPOUNDS

ALBERT LEA, MINNESOTA

LIST NO. 75 ON INFO-COUPON PAGE 61

TECHNIC

Soluble Rhodium

For Industrial and Decorative Electroplating

THE WORLD'S BEST SOLUBLE GOLD AND RHODIUM

TECHNIC INC.

Providence, Rhode Island, U.S.A.

JAckson 1-4200

LIST NO. 116 ON INFO-COUPON PAGE 61

RUST-LICK IN AQUEOUS SYSTEMS

Grade "C-W-25"

Non-flammable

Non-toxic

Aqueous Oily Film Protects Ferrous Parts for Long Periods Indoor Storage

Write for free sample and brochure Specify Grade "C-W-25"

PRODUCTION SPECIALTIES, INC.

755 BOYLSTON STREET

BOSTON 16 MASS

LIST NO. 121 ON INFO-COUPON PAGE 61

MANHATTAN

Abrasive Wheels — Cut-off Wheels Finishing Wheels—Diamond Wheels

Custom-made for your specific material removal problems

Foundry Snagging—Billet Surfacing—Centerless Grinding

Cutting and Surfacing concrete granite, and marble

"Moldiscs" for rotary sanders

Grinding and Finishing stainless steel welds

Bearing Race Grinding and Finishing

Finishing Tools and Cutlery

Cutting-off—Wet or Dry Bars, Tubing, Structurals, etc. Foundry Cutting —standard and reinforced wheels

Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.

MANHATTAN RUBBER DIVISION

92 TOWNSEND ST. • PASSAIC, N. J.

LIST NO. 1 ON INFO-COUPON PAGE 61

Prove it!

Prove to your own satisfaction that the MOLYKOTE line of industrial lubricants is one of the most spectacular contributions to metal progress in many decades. Send for free literature today and then order a trial supply.

MOLYKOTE®

INDUSTRY'S MOST VERSATILE LUBRICANT

The tremendous lubricity of MOLYKOTE depends on the unique molecular structure of the compound. Read the story behind its development and the jobs it can do better than any other lubricants.

Send for free catalog today!

THE ALPHA CORPORATION

LIST NO. 110 ON INFO-COUPON PAGE 61

BRIGHT HARDENING SPECIALISTS

THESE Stainless Steel Aircraft Parts, Hardened at 3000° and Over, Remain Sparkling Bright With No Appreciable Size Change . . . A Tribute to STANDARD'S Craftsmanship and Exclusive Processing.

YOUR SAMPLES PROCESSED FREE OF CHARGE

STANDARD STEEL TREATING CO.

3467 LOVETT AVE DETROIT 10, MICH

Phone TAshmoo 5-0600

LIST NO. 40 ON INFO-COUPON PAGE 61

WHITELIGHT
MAGNESIUM

your comprehensive independent source of magnesium alloy
Tubes • Rods • Shapes • Bars
Hollow Extrusions • Plate • Sheet
• Pipe • Wire • Welded and
Riveted structures and assemblies

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.
82 Moultrie St., Brooklyn 22, N. Y.
Sales Office
376 Lafayette St., New York 3, N. Y.

LIST NO. 67 ON INFO-COUPON PAGE 61

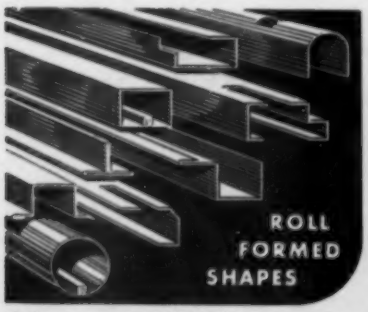
STATISTICAL QUALITY CONTROL

To ensure uniform high quality and closer tolerances, American Non-Gran Bronze uses statistical quality control in its contract machine work. Learn what this can mean to your product. Write! AMERICAN NON-GRAN BRONZE CO., Berwyn, Pa.

NON-GRAN

Write for book "Our Story in Pictures"

LIST NO. 3 ON INFO-COUPON PAGE 61



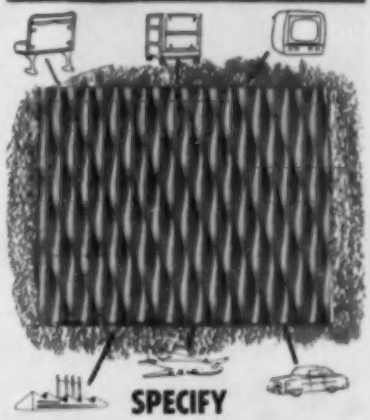
Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

LIST NO. 101 ON INFO-COUPON PAGE 61

STRENGTHEN BEAUTIFY PROTECT your product



SPECIFY

RIGID-tex METALS

Take that new product of yours, make it dent-scuff-scratch-resistant, give it plenty of rugged impact resistance, reduce its weight and double its strength, and finish it up by packing it full of buying-eye appeal. You can do *all* this when you specify Rigid-Tex Metals right into your product designs! Find out for yourself.

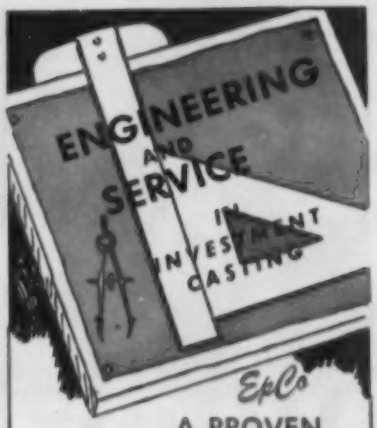
Send for new 16-page complete catalog—on company letterhead, please—or see Sweets Catalog 1a/Ri.

LIST NO. 64 ON INFO-COUPON PAGE 61

Star STAINLESS SCREW CO. Little Falls 4-2300

647 Union Blvd., Paterson 2, N.J.
Direct NEW YORK Telephone: WI 7-9041

LIST NO. 99 ON INFO-COUPON PAGE 61



A PROVEN DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING Special Feature —Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.

ENGINEERED PRECISION CASTING CO.

MORGANVILLE, N. J.

LIST NO. 4 ON INFO-COUPON PAGE 61

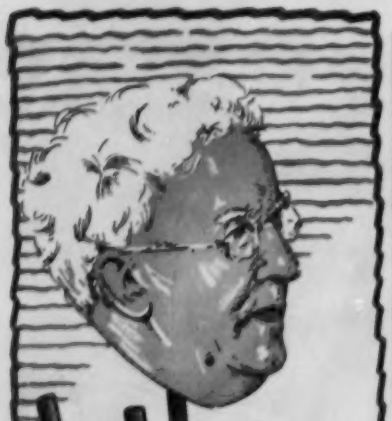
ask **SESSIONS**
HOW
STAMPED ASSEMBLIES SAVE TIME & MONEY

Send samples or prints for quotations on special stampings and sub-assemblies.

J. H. SESSIONS & SON

291 RIVERSIDE AVENUE • BRISTOL, CONN.

LIST NO. 119 ON INFO-COUPON PAGE 61



Call on Mr. Electrode

See Maurath, Inc. For

Stainless and Heat Resistant
ARC WELDING ELECTRODES

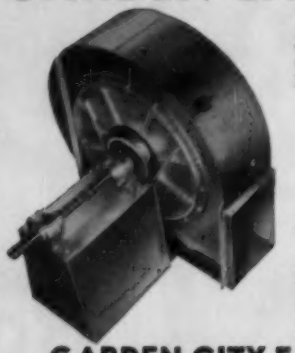
• • •

AUTOMATIC WELDING
All Analyses - Coated, Straightened - Cut - Coiled and Spooled

MAURATH, Inc.
21830 MILES AVENUE
NORTH RANDALL 22, OHIO
Phone: MOntrose 2-6100

LIST NO. 72 ON INFO-COUPON PAGE 61

GARDEN CITY Industrial FANS



For a wide choice . . . GARDEN CITY FANS designed with FORWARD — BACKWARD — or RADIAL BLADES, serve many industrial processing requirements.

If your needs call for HIGH TEMPERATURES (300° to 1600°F) you'll find GARDEN CITY HIGH TEMPERATURE FANS save you money. Patented air-cooled shaft slices maintainence costs.

Send for our latest catalogs, illustrating GARDEN CITY INDUSTRIAL FAN equipment. For specific details, outline your fan problems to us, giving cubic feet per minute, static pressure, and just how you intend to use the fan. We'll be pleased to suggest a fan for you.

GARDEN CITY FAN COMPANY
332 South Michigan Avenue — Chicago 4, Illinois
Representatives in principal cities

OUR DIAMOND 75 YEARS ANNIVERSARY

LIST NO. 123 ON INFO-COUPON PAGE 61

GET A BID FROM
HOOVER
SPECIALISTS IN THE FIELD OF
Die Castings
SINCE 1922
Aluminum and Zinc

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio

LIST NO. 74 ON INFO-COUPON PAGE 61

USE OUR
HOEGANAES
SPONGE IRON POWDER
for
Powder Metallurgy Fabrication
and other
Metallurgical Purposes

EKSTRAND & THOLAND, Inc.
441 Lexington Avenue
New York 17, N. Y.

LIST NO. 63 ON INFO-COUPON PAGE 61

"SILVERCOTE"®
BERYLLIUM COPPER
TITANIUM • BRONZES • ALUMINUM
COPPERWELD • SILVER PLATED WIRES
OTHER NON-FERROUS
ROUND WIRE FLAT
for
* SPRINGS
* FORMS
* ELECTRONICS
* SPECIAL PURPOSES

LITTLE FALLS ALLOYS
INCORPORATED
189 Caldwell Ave. • Paterson 1, N. J.

LIST NO. 66 ON INFO-COUPON PAGE 61

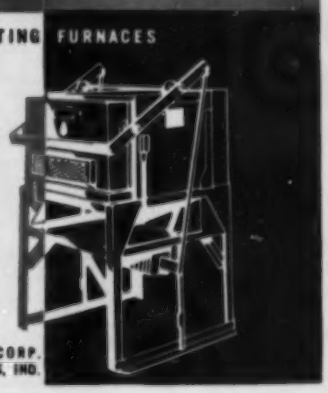
A CABLE SPLICED IN 10 SECONDS!

ERICO PRODUCTS, INC.
Complete Arc Welding Accessories
2070 E. 61st Place, Cleveland 3, Ohio
Write for Caddy Catalog

LIST NO. 71 ON INFO-COUPON PAGE 61

Expand Your Plant Potential

WITH *Cooley* ELECTRIC HEAT TREATING FURNACES



fast . . . inexpensive way to expand your plant facilities. Choose from 27 Models.

For Instance:

1. You save time and money by keeping heat treat jobs for small parts in plant.
2. It's easy to establish a new department at small cost in proportion to benefits which result.
3. Cooley heat treat furnaces pay for themselves through savings in time and subcontracting costs.
4. Heat treat operations are easily performed with Cooley designed furnaces.

Write now for Catalog giving complete details.

Cooley ELECTRIC MANUFACTURING CORP.
38 SO. SHELBY ST. • INDIANAPOLIS, IND.

LIST NO. 87 ON INFO-COUPON PAGE 61

Style #13 in salt hardening bath application.

FOR ALL YOUR BASKET and FIXTURE NEEDS . . .

Call Wiretex

Wiretex has the facilities to serve your every need. Small, large, standard or custom built. To resist acid, heat, abrasion or exposure. In every weave, metal and alloy. Prove it to yourself—send for the new "Wiretex" catalog.

BASKETS • RETORTS
MUFFLES • GRIDS
SCREENS • RACKS

for Quenching, Carburizing, Salt Bath, Dry Heat Applications, etc.

Representative Inquiries Invited.

Specialists in Processing Carriers Since 1932

Wiretex

5 Mason St., Bridgeport 5, Conn.

LIST NO. 114 ON INFO-COUPON PAGE 61

in one continuous operation

AUTOMATICALLY

Parts are conveyed automatically through 2 gas-fired hardening furnaces and into the quench tanks, from which the lines converge for direct conveyance to the **METALWASH** Spray Washer, where quenching oil is removed prior to tempering.

The **METALWASH** Spray Washer conveys the work directly into the continuous tempering unit. Combination washing and tempering machines also available.

Write today for information about the **METALWASH** way to *Heat, Quench, Wash* and *Temper* AUTOMATICALLY.

METALWASH
Quench Tanks and Tempering Units ®
WASHING PICKLING DRYING
PHOSPHATIZING DEGREASING

METALWASH MACHINERY CORPORATION
908 North Avenue, Elizabeth 4, N. J.
In Canada, Canefco, Ltd., Toronto, Ontario

LIST NO. 117 ON INFO-COUPON PAGE 61

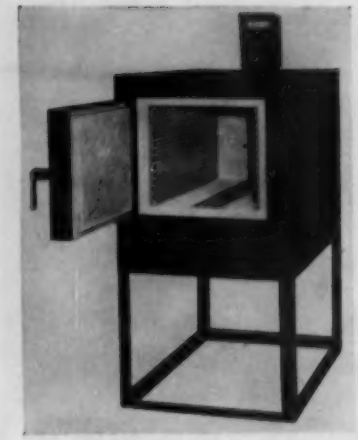
and STANWOOD has the Experience!

For nearly a quarter century Stanwood Heat Treating Equipment has been the standard in Heat Treating Shops — job and captive shops — all over the country. Stanwood has designed and built every conceivable type of basket, tray, fixture, and carburizing box to handle parts through heat treating, as well as retorts and furnace parts. Look to Stanwood for a practical, economical solution of your problems. Write for catalog.

Stanwood Corporation

4817 W. Cortland Street, Chicago 39, Illinois

LIST NO. 12 ON INFO-COUPON PAGE 61



More than two thousand satisfied users WILL TESTIFY YOU

SAVE 3 WAYS WITH A LUCIFER FURNACE

1—Save on First Cost

CHECK THESE PRICES

Furnace Size	2000°	2300°
6x 6x12"	$ 600.00	$ 800.00
9x 9x18"	750.00	950.00
12x12x24"	1000.00	1100.00
18x18x36"	1500.00	1600.00

Complete with 100% automatic electronic controls.

2—Save on Man Hours

Less operator attention needed—Lucifer controls are EXACT. They reach SPECIFIED heat rapidly and retain SPECIFIED temperature without variation. No special experience required when you use a Lucifer Furnace.

3—Save on Maintenance

Finest refractory materials are built into Lucifer Furnaces for better, more efficient heat retention. Elements are guaranteed, long lived, trouble free.

WRITE FOR FREE LITERATURE, specifications and price list of Lucifer Furnaces in wide range of sizes—top loading and side loading types. Engineering advice without obligation. Write, wire or phone today.

LUCIFER FURNACES, INC.

[illegible] 7, PA.

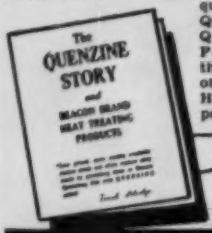
[illegible] Osborne 5-0411

LIST NO. 122 ON INFO-COUPON PAGE 61

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



ALDRIDGE INDUSTRIAL OILS, Inc.

3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 61

DEMPSEY FURNACES

GAS, OIL AND ELECTRIC

BATCH • CONTINUOUS

ATMOSPHERIC-RECIRCULATING-PUSHER—ROTARY HEARTH—CONVEYOR—RADIANT TUBE—POT CAR-BOTTOM-ALUMINUM REVERBS.

"Tailored by Dempsey"

DEMPSEY INDUSTRIAL FURNACE CORP.

Springfield 1, Mass.

LIST NO. 79 ON INFO-COUPON PAGE 61

CIRC-AIR

HEAT TREATING FURNACES

for Every Heat Treating Process

★

CONTROLLED ATMOSPHERES

★

DIRECT FIRED

★

CIRC-AIR DRAW FURNACES

★

CIRC-AIR NICARB (CARBONITRIDING)

Specially Engineered for Your Particular Needs

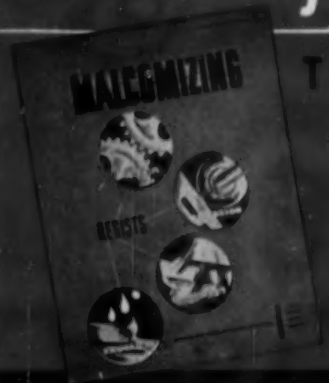
GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT COMPANY

1970 Proctor Pl. • Detroit 7, Mich.

LIST NO. 19 ON INFO-COUPON PAGE 61

JUST PUBLISHED . . .



THE STORY OF MALCOMIZING

(for surface hardening stainless steels)

what it is . . what it does . . how it works . . how you can use it.

Write today for your copy of this 24-page booklet. Specific subjects discussed include . . . pretreating the steels . . . selective Malcomizing . . . case depth . . . wear resistance . . . corrosion resistance . . . passivation of Malcomized steels.

A special "case history" section shows how nationally known manufacturers are specifying Malcomizing for the surface hardening of stainless steels.

Lindberg Steel Treating Co., covering industrial America from coast to coast, with plants in Rochester, Chicago, St. Louis and Los Angeles, is now licensed to Malcomize for its customers. For particulars call your nearest Lindberg plant.

LINDBERG STEEL TREATING COMPANY

Melrose Park, Ill. (Chicago), 1969 N. Ruby. Phone: Fillmore 4-6088. St. Louis 10, Mo., 660 E. Taylor. Phone: Evergreen 2-6200. Los Angeles 22, Calif., 2910 So. Sunol Drive. Phone: Angelus 9-7511. Rochester 11, N.Y., 620 Buffalo Rd. Phone: GIbraltar 5212.

CHICAGO • LOS ANGELES • ROCHESTER • ST. LOUIS

LINDBERG STEEL TREATING CO.

LIST NO. 38 ON INFO-COUPON PAGE 61

Makes SMALL PARTS GROW . . . in Value!

Carbonitriding by

LAKESIDE

Plus these comprehensive, complete scientific steel treating services: Electronic Induction Hardening, Carbonitriding, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Sand Blasting, Laboratory Physical Testing.

THE *Lakeside Steel Improvement Co.*

5418 LAKESIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100

LIST NO. 43 ON INFO-COUPON BELOW

Upton

. . . . OFFERS

the most advanced Salt Bath **Furnaces**

FOR . . . .

BATCH TYPE WORK

o

CONVEYORIZED TYPE WORK

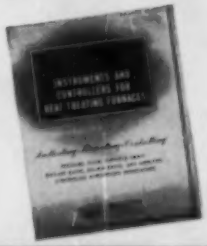
o

ALUMINUM BRAZING

UPTON ELECTRIC FURNACE CO.
16808 Hamilton Avenue
Detroit, Michigan
Phone: Diamond 1-2520

LIST NO. 20 ON INFO-COUPON TO RIGHT

Instruments and Controllers for heat treating furnaces



A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

Write for bulletin 51-750-81

THE HAYS CORPORATION
Michigan City 24, Indiana

LIST NO. 30 ON INFO-COUPON BELOW

READERS' INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

(Bulletin Board Item Number)	Send Catalog or Engineering Data (Please check)	Send Price Info	Nearest Source of Supply
_____	☐	☐	☐
_____	☐	☐	☐
_____	☐	☐	☐
_____	☐	☐	☐
_____	☐	☐	☐

Your Name _____ **Title** _____

Company _____

Street _____

City _____ **Zone** _____ **State** _____

THE IDEAL METHOD:

INDUCTION MELTING

for all metals...

Fast, efficient melting

Exact reproduction of analysis

Positive temperature control

Minimum metal loss

Highest production rates

Sizes from 8 ozs. to 8 tons

Write for information

AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING

AJAX ELECTROTHERMIC CORPORATION • TRENTON 5, NEW JERSEY

546

ASSOCIATED COMPANIES: AJAX ELECTRIC FURNACE CORPORATION • AJAX ELECTRIC COMPANY • AJAX ENGINEERING CORPORATION

Photo courtesy of
Caterpillar Tractor Co.

Where abrasion resistance is demanded . . .

Latrobe's BR-4* FM *does a better job!*

BR-4 FM conveyor belt plates last 6 times longer at CATERPILLAR TRACTOR CO.

At Caterpillar Tractor Co., regular mild steel plates (approx. ¼" x 2" x 4") were formerly used on the conveyor carrying track link forgings through the induction hardening machine. These plates, subject to continual abrasion, only lasted 40 to 100 days, after which they were replaced.

Since using hardened BR-4 FM plates, no replacements, due to wear, have been required in over a year. Machine maintenance costs have been greatly reduced . . . another example of the economy possible when you select Latrobe's BR-4 FM die steel for special wear resistant applications.

One of Latrobe's "free-machining" high alloy die steels, BR-4 FM was developed especially for applications involving extreme abrasive wear such as brick mold liners, shaving dies, stamping dies and deep drawing dies. As the result of the "DESEGATIZED" process, this high vanadium—high chromium die steel is uniform throughout thereby assuring equally high abrasion resistance on all surfaces, freedom from distortion and greater ease of heat-treating. Why don't you specify BR-4 on your next abrasion resistant application?

Call your nearest Latrobe representative for complete details—Branch offices located in principal cities.

Latrobe
STEEL COMPANY
LATROBE, PENNSYLVANIA

**Alloy Patented—U. S. Pat. No. 2575218*

Electro-magnetic support holds cassette mounted with "Patterson" 245 Screens to boiler wall. Technician Thomas Young positions x-ray tubehead.

Each cassette is loaded many times every day. Chief Radiographer Harold Bennett finds "Patterson" screens have outstanding grime resistance.

Du Pont Technical Representative "Chick" Nutting discusses the installation of "Patterson" screens with Chief Radiographer Harold Bennett.

"Despite grime, metal dust and constant daily handling, we've found

Du Pont 'Patterson' screens outlast others 3 to 1!"

says Chief Radiographer Harold Bennett, E. Keeler Company, Williamsport, Pa.

Radiographic screens take a daily beating at the E. Keeler boiler plant in Williamsport, Pa. X-ray inspection is carried on right in the shops—despite the metal dust, filings, oily soot, and grime that are a normal part of this large operation. Because of these conditions, Keeler insists on *durability* in choosing screens.

"The reason we switched to Du Pont 'Patterson' 245 Industrial Screens is simple," comments Chief Radiographer Harold Bennett. " 'Patterson' Screens last three times longer than any other screens we have used.

"Since we have almost fifty pairs of screens in constant daily use," continues Mr. Bennett, "we figure that the long life of our 'Patterson' Screens saves us well over a thousand dollars in replacement costs every year."

Like Mr. Bennett, you'll find that Du Pont "Patterson" 245 and the flexible 353 Screens are hard to wear out. Their hard, smooth surface resists abrasion, cleans quickly and completely. Specify Du Pont "Patterson" Industrial Screens on your next order. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. *In Canada: Du Pont Company of Canada Limited, Montreal.*

DISTRICT OFFICES

Atlanta 5, Ga.	805 Peachtree Building
Boston 10, Mass.	140 Federal Street
Chicago 18, Ill.	3289 N. California Avenue
Cleveland 14, Ohio	1033 Union Commerce Bldg.
Dallas 7, Texas	1628 Oak Lawn Avenue
Los Angeles 38, Calif.	7051 Santa Monica Boulevard
New York 11, N. Y.	248 West 18th Street
Philadelphia 2, Pa.	225 South 15th Street
Export	Nemours Bldg., Wilmington 98, Delaware

DU PONT
X-RAY
PRODUCTS

X-RAY FILM • CHEMICALS
"PATTERSON" SCREENS

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

spot the champ

... and with high speed steels the champion's always REX

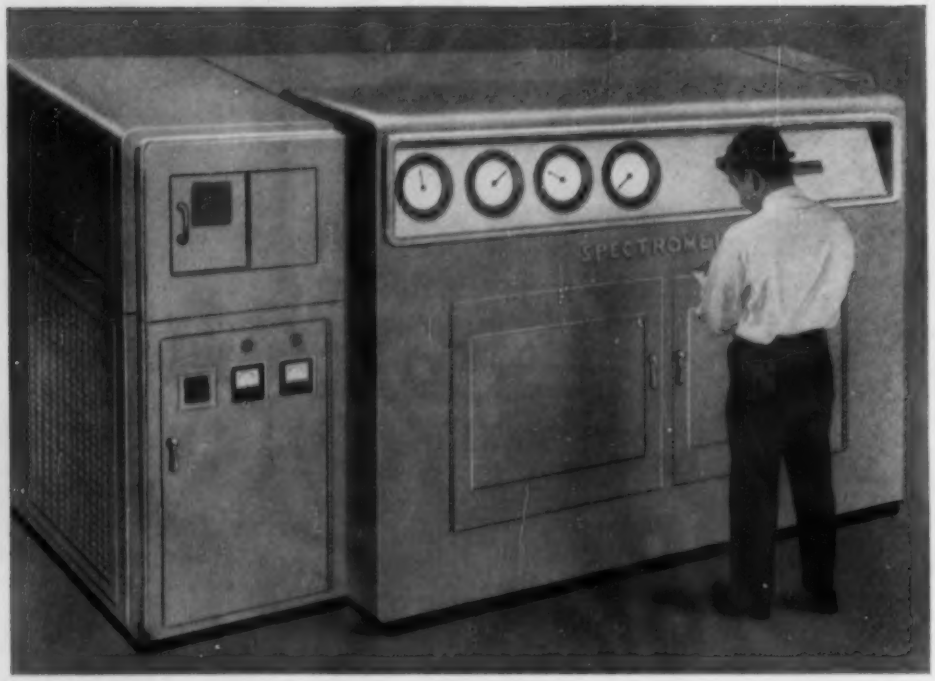
Compare the freckles and you'll pick the champ. And it's easy to spot the champ in high speed steels, too, for Crucible REX® has been the *standard of comparison* for over half a century.

Prove the reasons for REX's superiority in your own shop. You'll like its hardenability . . . response to heat treatment . . . fine tool performance. Like thousands of other users, you'll agree *you can't find a high speed steel to outperform REX.*

Ask for REX, a *prescription-made* Crucible product, at Crucible warehouses or leading distributors from coast to coast. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



Baird Associates Presents...

Quality Control On The Production Floor

With the new Baird Spectromet*, spectrochemical analysis is possible directly on the floor of the foundry and in the meltshop. Thirty to forty seconds after the sample is burned, the concentrations of six elements in the sample are read from indicators located on the face of Spectromet*. The indicator readings can be easily and rapidly translated into accurate corrections in the melt and give constant control of the contents of the melt.

The speed of the instrument's operation permits as many as 180 determinations per hour providing practical analytical data at low cost per sample.

Sealed optical and electronic compartments provide a built-in laboratory environment. Maintenance is reduced to a minimum.

For more information why Spectromet* can help serve your analytical needs, write for free technical Bulletin #42.

Visit Booth 25, 26, 27
Pittsburgh Analytical Exposition
March 1-4, 1955

Baird Associates, Inc.

33 University Road · Cambridge 38, Mass.

*Trade Mark

NOW— *from Borg-Warner's centrally located Ingersoll Steel Division, at New Castle, Indiana...*

FORGING QUALITY

INGOTS

UP TO

23,000 POUNDS

to your own analysis

If you've been looking for a dependable source for ingots of superior forging quality, it will pay you well to see how Ingersoll can serve you with:

- **Electric furnace carbon steel or alloy grades to your own analysis and specifications.**
- **Ingots in any size and shape from 400 pounds to 23,000 pounds.**
- **Great flexibility in production schedules—set up to fit in with your own forging requirements.**
- **Ample capacity to meet your needs . . . on schedule.**
- **The assurance of uniform high quality from one heat to the next.**

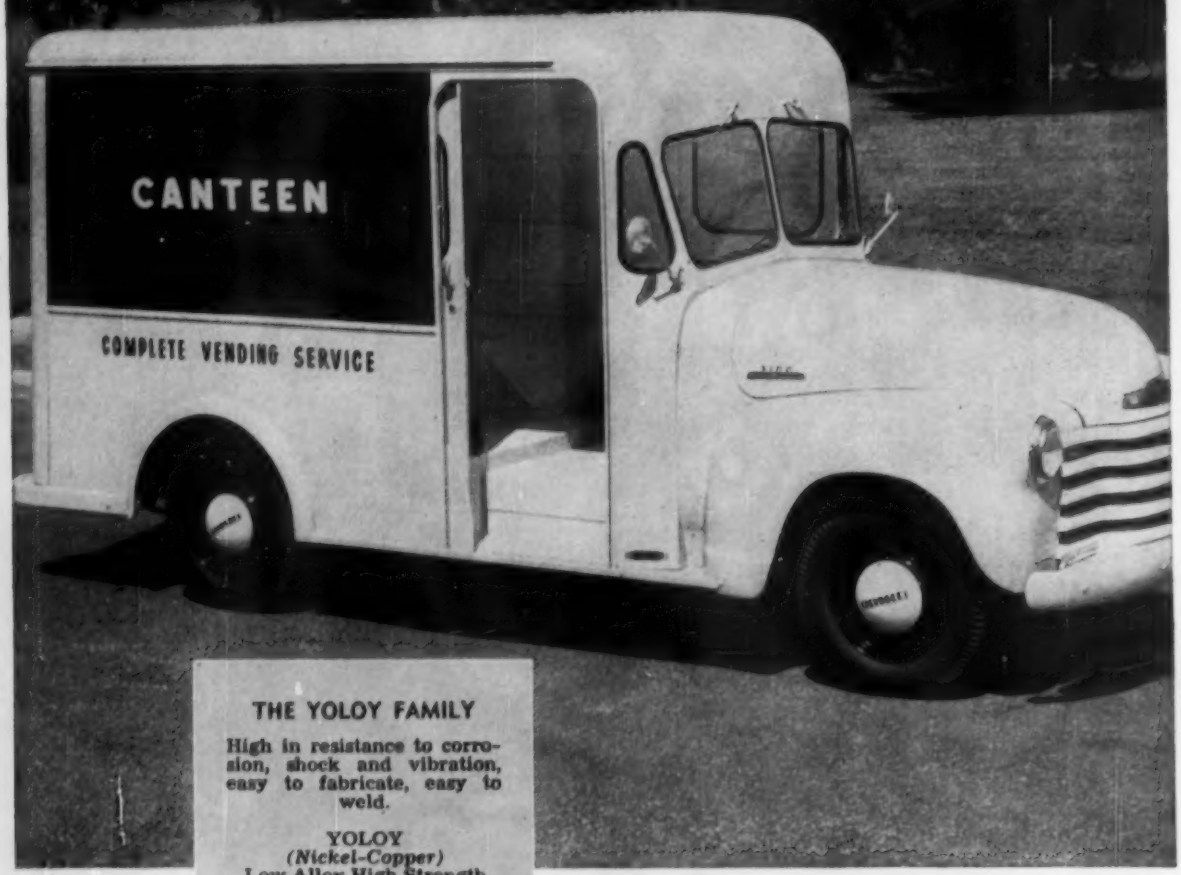
FOR FULL DETAILS—WRITE, WIRE OR PHONE—NOW

Ingersoll
STEEL DIVISION
Borg-Warner Corporation
New Castle, Indiana

alloy steels • armor plate • carbon electric steel for tank clutch discs • clutch plate steels • heat-resisting steels • IngAclad stainless-clad steel • knife steels saw steels, including high speed hack saw blade steels shovel steels • soft center steel • stainless steels Tem-Cross cross-rolled steel • tillage steels.

"Yoloy E sheets - ideal for truck bodies..."

says Boyertown Auto Body Works of Boyertown, Pennsylvania



THE YOLOY FAMILY

High in resistance to corrosion, shock and vibration, easy to fabricate, easy to weld.

YOLOY
(Nickel-Copper)
Low Alloy High Strength Steel

YOLOY E
(Nickel-Chrome-Copper)
Low Alloy High Strength Steel

YOLOY C
(Chrome-Copper)
Corrosion Resistant Steel

Body Model S-7, with load capacity of 187 cu. ft. Boyertown Auto Body Works, Boyertown, Pa.

YOLOY IS AVAILABLE in sheets, plates, strip, pipe, mechanical tubing, bars, shapes and cold finished bars.

Boyertown truck bodies, such as Model S-7 shown above, are serviceable for many EXTRA YEARS, because they are fabricated from Yoloy "E" sheets.

Due to its nickel-chrome-copper content, this tough corrosion-resistant, low-alloy high strength steel reduces dead weight, resists corrosion and lengthens body life. Yoloy "E" is also outstanding for its resistance to vibration and shock—even at the lowest outdoor temperatures.

For types of Yoloy available for prompt delivery, phone our nearest District Sales Office.

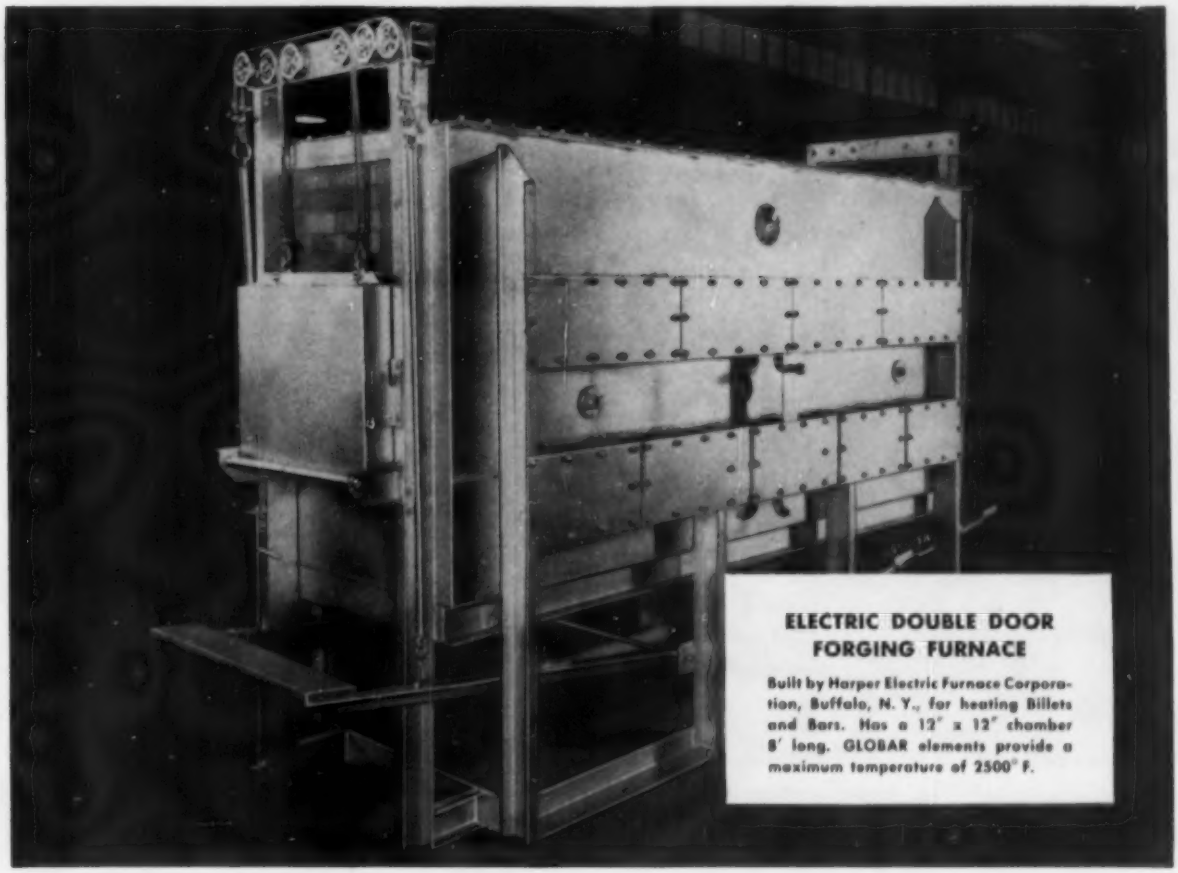
Youngstown

QUALITY V YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices: Youngstown, Ohio - Export Office: 500 Fifth Avenue, New York 36, N. Y.

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - BAR SHAPES - WIRE - HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - RAILROAD TRACK SPIKES



ELECTRIC DOUBLE DOOR FORGING FURNACE

Built by Harper Electric Furnace Corporation, Buffalo, N. Y., for heating Billets and Bars. Has a 12" x 12" chamber 8' long. GLOBAR elements provide a maximum temperature of 2500° F.

In this electric forging furnace,

GLOBAR®

Heating Elements

give you

1 **MORE UNIFORM HEATING** of hearth area.

2 **WIDEST RANGE OF TEMPERATURES...** up to 2750° F.

3 **SIMPLICITY** of furnace construction and operation.

4 **LESS DOWNTIME...** no need to cool or unload during replacement.

In this Harper furnace, you can maintain constant accurate temperatures at all times. Even more important, you are able to control the atmosphere *independently* of the temperature.

This means...in heating steels and alloys to forging temperatures...that you can prevent decarburization by means of a protective atmosphere while establishing definite reproductive quality control. The result...better, more uniform forgings.

To obtain these advantages, the Harper design incorporates the unique characteristics of GLOBAR silicon carbide heating elements. These non-metallic elements offer many other benefits as well. We'd like to tell you more about them...what they can do for you in a variety of heating applications. Write us at Dept. MP 87-51, The Carborundum Company, GLOBAR Division, Niagara Falls, N. Y.

GLOBAR®

Heating Elements

by CARBORUNDUM

REGISTERED TRADE MARK

Inconel averages nine months service in this D-shaped muffle used in gas-fired furnaces to continuously anneal strip at Somers Brass Company, Waterbury, Conn. Previous materials failed in weeks.

In goes Inconel... *Up* goes life of muffles

Somers Brass *finds way to offset triple attack on muffles where metal temperatures go up to 2200° F.*

This was a tough one . . .

Temperatures running as high as 2200°F. . . . superhot corrosive combustion gases outside the muffle . . . carbon rollers inside, plus hydrogen (from the cracked ammonia) to cause embrittlement.

Under such a three way attack, muffles cracked in a matter of weeks, destroying the integrity of the controlled atmosphere, spoiling the finish on strip being annealed.

With every muffle material Somers Brass tried, it was the same story . . . until they came to Inconel®. Inconel is giving them nine full months of service on the average, a big boost in production economy.

Inconel

Inconel steps up life in 3 ways

Inconel retains usable strength up to 2200°F. Inconel resists carburization and high temperature corrosion. Inconel withstands severe thermal stressing without cracking or spalling.

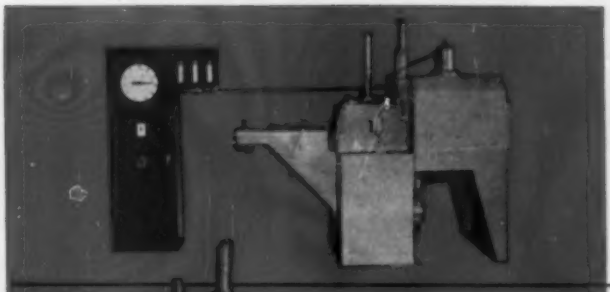
Do you need these properties, too?

If so, consider Inconel. It's an easy material to fabricate and keep in repair. Furthermore, there's an Inco booklet that suggests many ways to use Inconel effectively . . . "Keeping Operating Costs Down as Temperatures Go Up." Write for a copy today.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

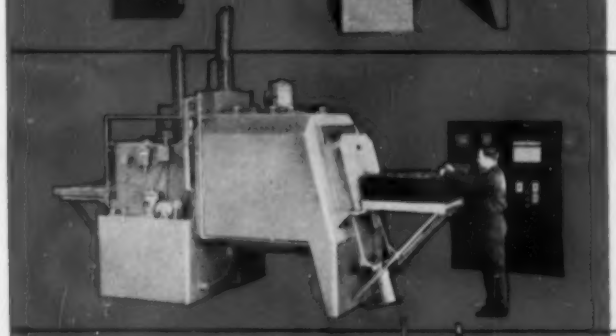
INCO NICKEL ALLOYS

. . . for long life at high temperatures



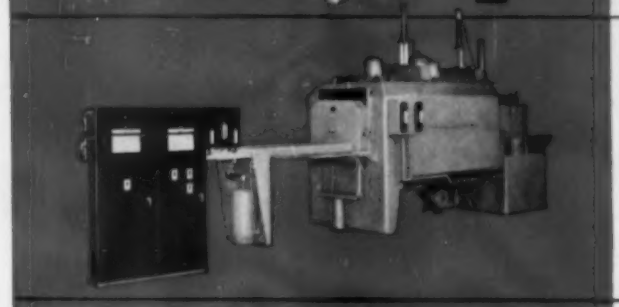
FROM 25 LBS/HR . . .

Controlled Atmosphere Ipsen Heat Treating Units start with models like this compact RT-25-E, especially designed for laboratory and tool work . . . a dependable, economical unit.



IN STANDARD UNITS . . .

Regardless of your heat treating production requirements, you'll find an Ipsen gas or electric unit that will fit your processing needs . . . like this popular T-400 unit illustrated.



UP TO 2000 LBS/HR . . .

For heavier production, Ipsen units have double heating zones, pre-heating chambers, and other features. All production units feature Ipsen patented transfer systems.

PLUS AUXILIARY EQUIPMENT . . .

Ipsen Gas and Electric Generators are made in sizes from 500 to 1200 C.F.H. Ipsen Carbotronik automatically controls carbon potential. Coordinated Ipsen Washers and Tempering Units complete the line.

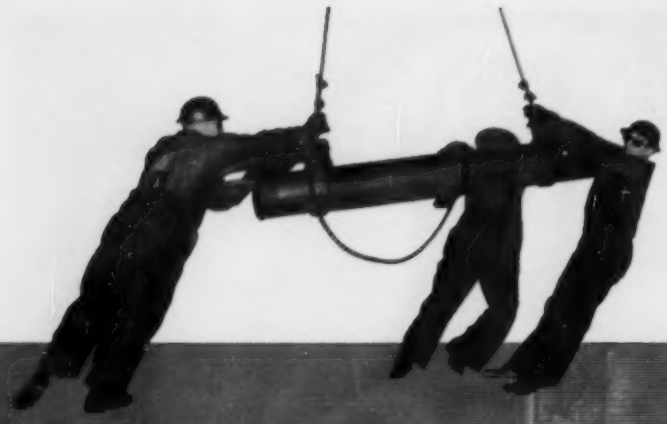
Ipsen — YOUR COMPLETE SOURCE FOR CONTROLLED ATMOSPHERE HEAT TREATING EQUIPMENT . . .

Ipsen Heat Treating Units will improve the quality and volume of your production . . . *and cut production costs.* We'll be glad to send you facts of actual installations. Or, send us samples. We'll process them and provide cost and procedure.

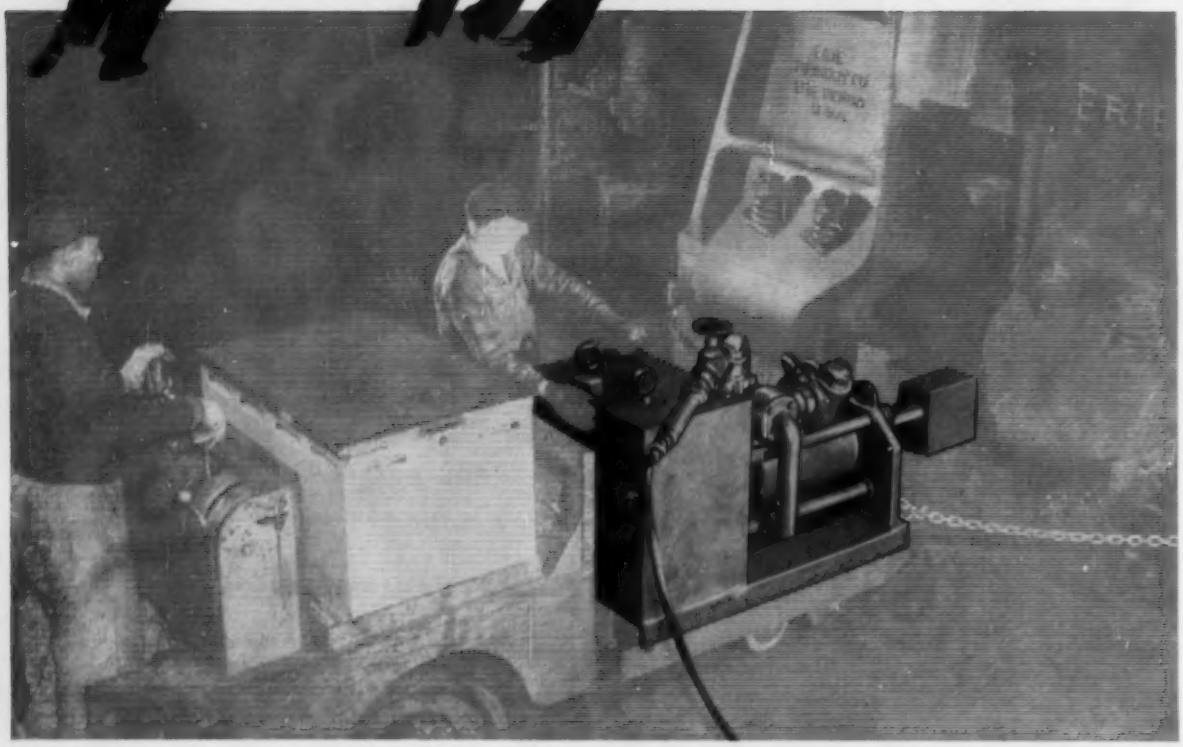
AUTOMATIC **Ipsen** HEAT TREATING UNITS

Write Today for Complete Details

IPSEN INDUSTRIES, INC.
723 SOUTH MAIN STREET, ROCKFORD, ILLINOIS



IF YOU ARE STILL LOSING 20 MAN-HOURS DRIVING KEYS . . .



THE NEW ERIE KEY DRIVER

lets you drive keys safely . . . . . in one man-hour

STOP DRIVING A SPIKE WITH A TACK HAMMER!

Now, when driving die and sow block keys in forge hammers, the new Erie Key Driver will do with *two* men in *15* minutes what used to take *5* men (don't forget the crane operator) several hours! Let Erie Foundry Co. show you how to save maintenance man-hours, eliminate wasteful down time, reduce accidents.

THE NEW ERIE KEY DRIVER IS SAFE

There's no danger of ram end-swing, no glancing blows, minimum mushrooming of keys. Every Erie Key Driver blow is true. One user says,* "The incidence of personal injury and property damage has been reduced to a relatively negligible nature by using the very efficient Erie Key Driver."

**Name furnished upon request.*

Write for Bulletin No. 356 today

ERIE FOUNDRY CO. ERIE, PA.

THE GREATEST NAME IN FORGE HAMMERS

ERIE

ROTOBLAST BLASTMASTER® BARREL. Mathews Heat Treating Co., Newark, N. J., saved $8,000 on one contract alone by using the Pangborn Blastmaster Barrel with Rotoblast.

wherever blast cleaning

ROTOBLAST TABLE-ROOM. Utica General Jobbing Foundry, Utica, N.Y., saves $1,200 a year in labor alone with Pangborn Rotoblast Table-Room.

Pangborn

BLAST CLEANS CHEAPER

Rotoblast Blastmaster & Continuous-Flo Barrel | Rotoblast Tables & Table-Rooms | Special Blast Rooms & Cabinets | Pangborn Dust Control Equipment | Mollenbrasive* Shot & Grit

Look for Pangborn Rotoblast®

Throughout the country—in small foundries and large ones, cleaning ferrous and non-ferrous pieces, handling castings, forgings, heat treated parts—Pangborn Rotoblast cuts operating costs for foundrymen. But Rotoblast offers more than versatility. This exclusive Pangborn process utilizes centrifugal force for thorough, efficient blast cleaning . . . throwing a great volume of abrasive over a large area with heavy density. It eliminates air compressor investment, saves labor costs, requires less power to operate. The result is *better* cleaning done quickly and cheaply. See how Pangborn Rotoblast can cut blast cleaning costs and save *you* money!

is done faster and cheaper

For faster, cheaper cleaning, investigate Pangborn Rotoblast now. Write today for Bulletin 214 to: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md.

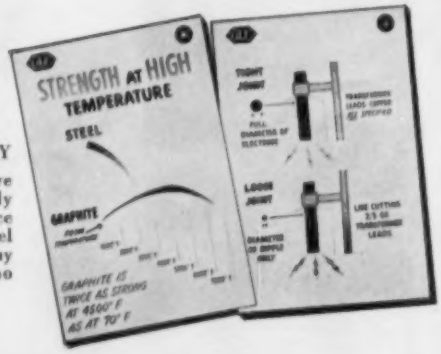
*U. S. Patent 2184098 (other patents pending)

MAKE YOUR ELECTRODES STOP LOAFING!

Let your men see and hear *The Electrode Story* — a shop-level informational program aimed at developing optimum electrode service for electric steel producers.

This series of four illustrated talks — developed especially for melt shop personnel — gives the men-on-the-furnace a better knowledge and understanding of electrode handling and joint assembly.

***The Electrode Story* was developed to help effect important economies in electrode utilization, and thus contribute to the advancement of the electric steel industry as a whole. It is being made available to electric furnace steel producers without charge or obligation. This forward-looking program can help your company get optimum service from electrodes and substantially reduce electrode costs.**



Typical Panels From THE ELECTRODE STORY

Two of the many informative panels that dramatize simply yet forcefully the importance of electrodes in electric steel making, and the reasons why proper shop practice is so important.

Inquiries about *The Electrode Story* are most cordially invited. Write to . . .

ELECTRODE DIVISION

Great Lakes Carbon Corporation

GLC

18 EAST 48th STREET • NEW YORK 17, NEW YORK

JOIN THIS RAPIDLY GROWING GROUP OF ELECTRIC STEEL PRODUCERS who have benefited from *The Electrode Story* informational program.

Allegheny Ludlum Steel Corporation
Copperweld Steel Company
Crucible Steel Company of America
Firth Sterling Inc.
Fort Pitt Steel Casting Co.
Jessop Steel Company
McQuay-Norris Manufacturing Co.
National Malleable and Steel Castings Company
Newport Steel Corporation
Northwestern Steel & Wire Company
Rotary Electric Steel Company
St. Louis Steel Casting Company
Sterling Steel Casting Co.
. . . and many others

HERE'S WHAT ELECTRIC STEEL PRODUCERS SAY ABOUT *The Electrode Story*

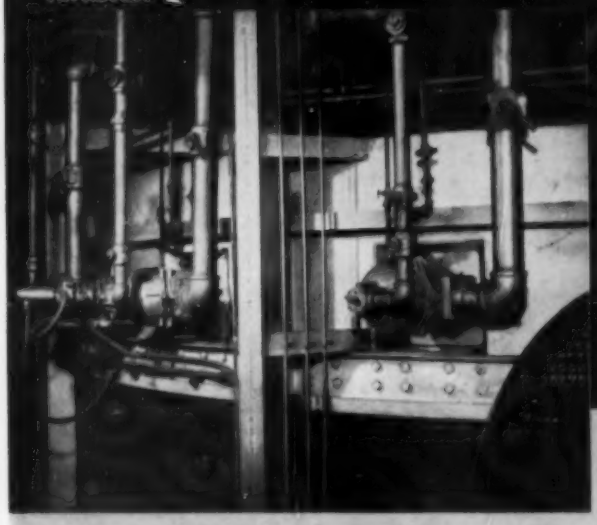
". . GLC is setting the pace on education within the industry."
". . brings home to the men the importance of proper handling of materials."
". . the improvements were very noticeable."
". . is proving helpful in reducing consumption."
". . has shown marked improvements in the Melting Department."
". . one of the best things that ever happened to educate the men on the furnace."
". . the results of the lectures are noticeable daily in the extra care taken in handling and assembling electrodes."
". . a model of the use of visual aids and of conference and discussion techniques."
". . the men are more careful now."
". . proved very beneficial in better handling of electrodes."

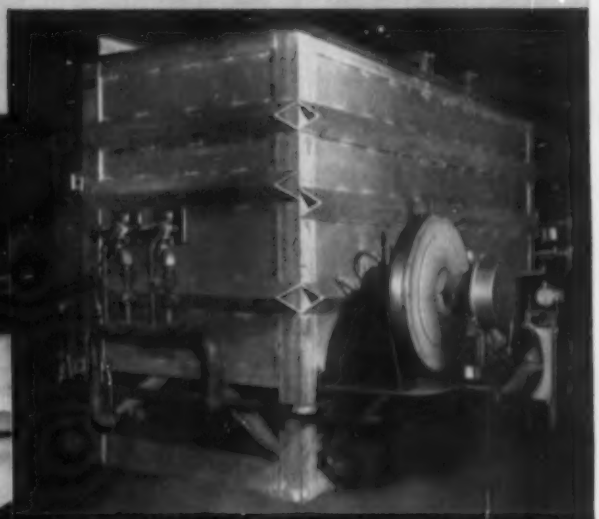
"Great Lakes takes the long-range view that it is better to sell an extra carload of electrodes because a customer has added another furnace, than because he is getting less-than-optimum service out of his existing equipment"— from an article in STEEL.

North American

BURNERS

Series 212 burners are used extensively on slot forge furnaces at Ford's Canton Plant.← Luminous Flame Burners fire five rotary furnaces.→





Scores of North American heavy duty Series 300 Turbo Blowers supply air for combustion throughout Ford Motor Company's Forge Plant at Canton, Ohio.

BLOWERS

have proven their reliability at

Ford's Canton Forge Plant

Gas, Oil and Dual-Fuel Burners — rugged dependable design — 7,000 to 15,000,000 Btu per hour.

Heavy Duty Turbo Blowers — low maintenance — 4 to 32 ounces per square inch — 60 to 7560 cfm.

Complete Combustion Systems - One Responsibility

The NORTH AMERICAN *Manufacturing Company*

4455 East 71st St. · Cleveland 5, Ohio

What's New in Steel Service

Again in 1955, as in every year since 1842, Ryerson is setting the steel-service pace. Many advances in our ability to serve you have been made in recent months—many more are immediately ahead. Briefly, here is what you can expect:

EXPANDED STOCKS—Amazing new leaded alloys in three carbon ranges—carbon steel plates produced to an "easy-welding and forming" specification—304L and 316L stainless plates and sheets for superior welding characteristics—type 430 stainless sheets for those who want an alternate to higher priced 18-8 stainless. These are a few recent additions and further stock expansion is already under way.

NEW QUALITY SAFEGUARDS—Steel you order from Ryerson now protected by a whole new set of quality control standards—tighter than any thought possible before. As evidence of uniform high quality we can furnish a certificate of analysis or a mechanical properties report for every pound of steel we ship.

STEPPED-UP SERVICE—On 92 to 98% of the regular orders we receive, steel is cut and shipped the same or following day. With two new plants getting into operation, and with facilities enlarged and modernized from coast to coast, we'll do even better in the weeks ahead.

So here's our steel-service pledge to you—an even wider selection of steels, dependable high quality, delivery where you want it—when you want it—now and throughout 1955.

RYERSON STEEL

In stock: Bars, structurals, plates, sheets, tubing, alloys, stainless, reinforcing, machinery & tools, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • PHILADELPHIA • CHARLOTTE, N. C. • CINCINNATI • CLEVELAND
DETROIT • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Metal Progress

February . . 1955

Carbon–a Neglected Metallurgical Tool?

*By CARL E. SWARTZ**

As a material of construction, carbon has long been neglected. Few metallurgists realize its possible applications in their work, and fewer still have had any experience with it. Nevertheless, in the foundry, in the steel mill, in nuclear reactor technology and in various other metallurgical operations, it has many properties which make it a useful and economical material.

NEARLY all of us are familiar with certain properties of carbon – its hardness when crystallized in the form of diamond; its lubricating ability in graphite form; its uses as an alloying agent to produce hardness in steel, as a reducing agent in the smelting of metallic ores, for carbide cutting tools and carbide refractories, and for diamond cutting tools for hard metals. Many of us have read of the use of graphite as a moderator in nuclear reactors. Yet the average metallurgist is probably unfamiliar with its potential application in his own work and inexperienced in its use.

One of the reasons for this lack of utilization may be that carbon is unique among the elements – it does not properly fall into any class of materials, metallic or nonmetallic. It has been conveniently omitted from college courses on materials, certainly in the metallurgical curricula and probably in ceramic courses also. It is perhaps time for a discussion, even though it will be confined largely to graphite and carbon, their fabrication into shapes and their use in metallurgical processes.

The raw materials for carbon and graphite manufacture are many – natural and artificial graphite, lampblack, carbon black, charcoal, anthracite coal, bituminous coal, petroleum coke and metallurgical coke.

Sources of Carbon and Graphite

Natural graphite, after mining and dressing to remove the gangue, is ready for use. It falls roughly into three types – amorphous (actually microcrystalline), flake graphite (the shiny plates used in crucible manufacture and the form that most of us visualize as graphite), and crystalline (used in electric brushes, crucibles and some other refractories).

Artificial graphite, first made by Acheson about 1895, is produced by heating carbon to 5000 to 5500° F., where it changes into the crystalline form. It is used to make some electrodes and other massive parts requiring high conductivity, oxidation resistance, softness, lubricity, or ease of machining.

* Consulting Metallurgist, Hinsdale, Ill.

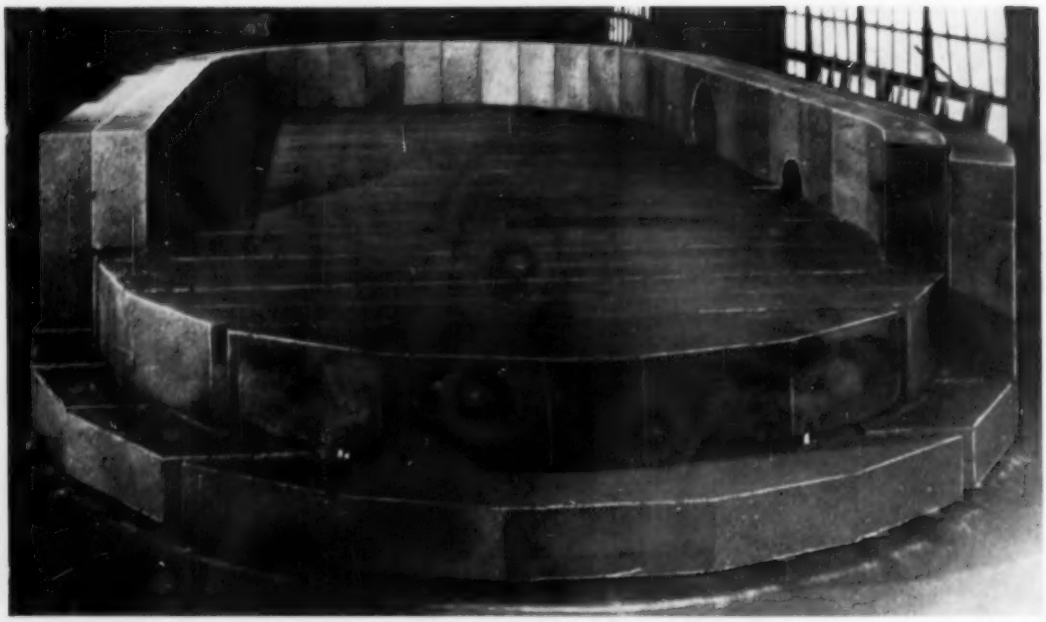


Fig. 1 – Construction of Carbon Lining for Electric Furnace. (Courtesy of National Carbon Co.)

Lampblack is a soft, fine carbon formed by burning oil or solid hydrocarbons with a deficiency of oxygen. The products of combustion are passed into a cold chamber, where the lampblack deposits on the walls. It is used in furnace insulation and in carbide manufacture and less often after pressing into massive shapes.

Carbon black is harder and finer than lampblack. It is made by burning natural gas in a deficiency of oxygen. The black is deposited when the flame impinges on a cold metal surface, and can be scraped off in a continuous process. It finds little use in massive shapes.

Charcoal, the residue from the destructive distillation of wood, is used in only minor amounts in industrial products because of its high cost. For special purposes, carbon is also made from other vegetable products, such as sugar and molasses.

Anthracite coal is widely used for manufacture of carbon electrodes and refractories because of its low cost and high fixed carbon, low volatiles and low ash content.

Bituminous coal is less desirable because it contains high volatiles, lower fixed carbon and higher ash than anthracite. It is usually used after conversion to metallurgical coke.

Petroleum coke, the residue from the distillation of oil, is an excellent material, but with the introduction of new processes for oil refining this product is becoming scarcer. It is hard and brittle, with a relatively low ash content as compared with metallurgical coke. It has been used for the manufacture of foundry cores and molds. Where sulphur is undesirable, low-sulphur material must be selected.

Metallurgical coke from bituminous coal is used as a reducing agent in metal recovery, and in making electrodes and other carbon shapes.

Bonding – Carbon and graphite have a high melting point or sublime before melting at about 6500° F. Partially because of this property, the material cannot be bonded to itself in the pure state, such as by sintering, and a bonding agent is necessary. Traditional binders are pitch and coal tars. The ingredients must be kept hot during mixing and forming and the bodies baked at a high temperature for a long time to drive off the volatiles and set the bond.

Thermal-setting resins, which polymerize at low temperature to form a bond, avoid this heating period. The resins as a class disintegrate at moderately elevated temperatures and are advantageous where it is necessary for a mold or core to collapse, but are at a disadvantage for permanent shapes such as blast furnace linings. Other binders are available for permanent cores and molds, and for collapsible cores and molds where castings are to be poured at very high temperatures. Such shapes can now be made in

the foundry by conventional methods without the expensive machining operations required on carbon blocks. Discarded molds and cores may be reground and used again.

Manufacture of Carbon Shapes

It may be well to examine the manufacturing methods briefly for the benefit of those who wish to make cores and molds in their own foundries.

Calcined petroleum coke and metallurgical coke can usually be obtained with the required screen analysis, but if broken cores and molds are to be reprocessed, crushing and grinding equipment will be essential. Electrode stubs and other carbon scrap can also be used. The material is broken down to 1 to 2-in. lumps in jaw and roll crushers, and then ground in impact pulverizers, Chilean mills or ball and tube mills. Only the most abrasion resistant equipment can be used. The mixing step may include some further grinding, although modern mixers, such as the spiral agitator mixer and the pug mill, do not significantly change the screen analysis.

The binder is then added to the carbon; since it is used sparingly, a liquid is sometimes added to disperse it. As mentioned above, the coal tar and pitch binders require hot mixing, handling at high temperature, and a long bake, whereas the plastics, certain clays and other inorganic materials can be added cold, and mixed and baked at lower temperatures for shorter times. For many structural and foundry uses, bodies bonded with these agents perform satisfactorily. Whatever the bonding agent, the body may then be formed by any of the common ceramic or foundry methods such as pressing, ramming or extruding.

The mechanism of bonding the carbon particles to make a single mass of the desired shape differs depending upon the type of agent. In the tar-pitch binder, volatilization and cracking of the hydrocarbons leaves a carbon residue which acts as the bond. In the plastic bond, the resins polymerize at low temperature to form a solid adhesive. With other agents, the bond may be derived from a sintering mechanism.

The baking furnace varies with the bonding agent. For the resin bond, an ordinary core-baking oven is satisfactory. For the tar-pitch bond, specialized furnaces available only in the carbon processor's plant are necessary. Other bonding agents may be "set" in ordinary electric or gas-fired furnaces. The charge must be supported so as to avoid distortion in the green bodies. To protect the pieces from oxidizing

Fig. 2 – Operator Inserting a Graphite Mold Into Head of Centrifugal Casting Machine

gases which would burn the carbon, they are packed or covered with a layer of coarse (¼ to 1/16-in.) carbon particles. To prevent the carbon particles from sticking to the bodies (which may occur at temperatures above 2000° F.) in the event that a low-melting ash happens to be present, small shapes can be wrapped in paper before the carbon protecting blanket is placed.

Metallurgical Uses of Carbon and Graphite

The properties of carbon that make it useful for molds, cores and furnace linings are its low coefficient of expansion and consequent thermal shock resistance, its non-wettability by fully reduced metals and neutral slags, its high abrasion resistance and its high-temperature strength and stability. Carbon and graphite at elevated temperatures react with oxidizing agents such as oxygen, water vapor, and many metal oxides to produce carbon monoxide and dioxide with consequent disintegration of the bodies. Therefore carbon is not suitable for high temperatures except in neutral or reducing atmospheres.

Although carbon is abrasive, it can be machined easily to close tolerances by conventional equipment and techniques.

In the Foundry – Some experimental installations have been made using carbon linings for

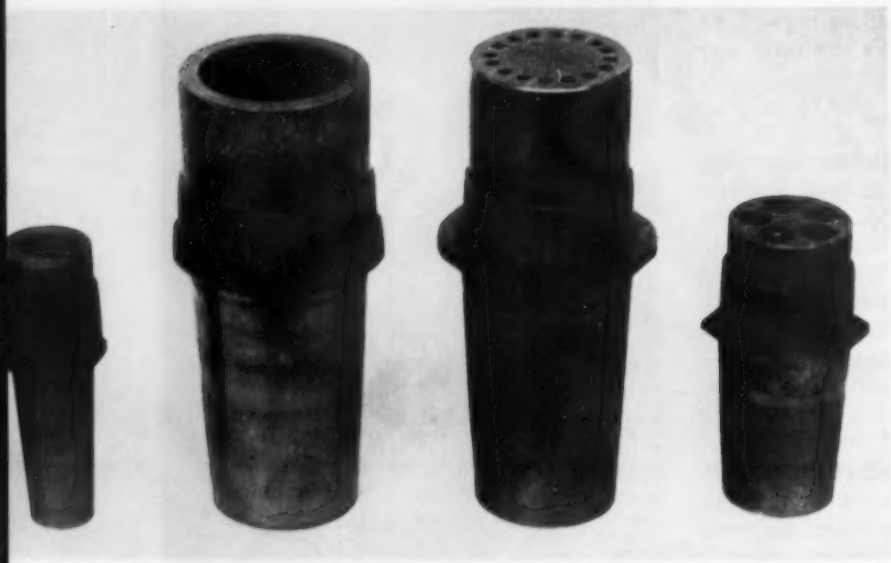


Fig. 3 – Graphite Dies Used in the Asarco Continuous Casting Process. (Courtesy American Smelting and Refining Co.)

the well, taphole and breast of the cupola; and slag dams, troughs and run-offs outside the cupola, similar to analogous parts in the iron blast furnace that have been used successfully. There is this difference, however – the cupola is run intermittently and on shutdown the hot lining is exposed to oxidizing air and gases. Therefore it is desirable to cool the carbon lining as rapidly as possible so that oxidation and burning may be kept to a minimum.

Carbon parts for cores and molds are being used successfully for casting aluminum, magnesium, copper, brass, bronze, iron and steel.

For collapsible molds petroleum coke of the proper screen analysis may be mixed with a plastic binder such as a phenol-formaldehyde resin, pressed or rammed into the desired shape, then heated at low temperature (350° F.) to polymerize and set the resin bond. During casting the heat from the molten metal decomposes the resin and the mold collapses. Although the use of carbon has not been reported in the shell-molding process, there is no fundamental reason why this cannot be done; the substitution of carbon for silica would avoid sand burn-in and would facilitate cleaning of the castings.

Use of carbon for permanent molds is increasing. Some small foundries have switched over completely, while others are using large numbers of carbon molds, particularly for casting aluminum. Still others use carbon inserts in metal molds. Carbon and graphite rods and slabs, easily and quickly made to the desired size and shape, may be purchased from various manufacturers. Advantages of carbon molds and inserts are freedom from warpage during heating and cooling, lightness and ease of handling, freedom from heat checking and cracking during casting, and no sticking to the casting.

Where volume of production is sufficient to justify it, core boxes and patterns may be made for pressing or ramming carbon grain and binder into cores and molds. Such parts may be used but once or as permanent molds. In large installations, processing machinery may be installed to grind the discarded parts to carbon grain for re-use. Molding, pressing and baking the parts avoid expensive machining operations and costly raw materials.

Mold dressings, facings and chills of carbon have been in use for many years – also carbon stopper rods, stoppers and nozzles, particularly in nonferrous foundries. Advantages are ease of machining, no contamination of the melt, no slag formation, no metal pick-up or adherence, and good thermal shock resistance.

For reasons that have not yet been fully explained, ceramic tubes fail when immersed in molten aluminum. Carbon tubes are a good substitute for the introduction of nitrogen and chlorine into aluminum melts for fluxing and degassing. These tubes introduce no contamination into the melt and are easily cleaned.

In the Steel Mill – For many years European blast furnaces have used carbon hearth linings, and some have been adopted in this country as

well. To reduce the number of joints in the lining, large blocks (up to 24×30×180 in.) are sometimes used rather than standard or oversized bricks for both the bottom and the sidewalls. Often the entire lining is assembled and the layout marked out before shipment to the job so as to insure an accurate fit of the carefully sized blocks, a minimum of joint clearance, and ease of assembly. These carbon hearths have long life and reasonable freedom from breakout. Since the hearth normally holds only molten material, erosion is negligible. Also, since the molten iron is saturated with respect to carbon, the slags above it do not react with the lining.

There has been some evidence of the gradual disappearance of bottoms between shut-downs for hearth inspection. This is believed to be caused by the slow graphitization of the carbon. Since graphite is much softer than carbon, and is susceptible to washing because of the low shear strength of the transformed graphite, the surface slowly disintegrates. The sidewalls of the hearth, being water-cooled, remain below the graphitization temperature, and thus last far longer. Since water cooling of hearth bottoms is impractical, it seems probable that standard refractory bottoms may be combined with carbon sidewalls.

Carbon cinder-notch liners, run-out trough liners, splash plates and skimmer blocks can withstand high temperatures without melting, slagging or warping and are easy to clean after the cast because the metal does not stick to them.

Carbon stool inserts for big-end-down ingots, mold plugs for closed-bottom ingot molds and even ingot molds of graphite have been successfully used in casting steel. Carbon pick-up seems to be negligible and other contamination is impossible if the molds and stools are kept clean. No mold wash is necessary, and sticking is nonexistent. Ingot surfaces that have solidified against carbon or graphite are free of laps, seams and pits.

The use of carbon and graphite electrodes in arc furnaces (and various reducing furnaces such as those used for aluminum) is well known and will not be discussed here.

In Continuous Casting – During the 1930's Poland, at American Smelting and Refining Co., developed a carbon-lined, graphite-resistor furnace for holding molten copper alloys immediately prior to continuous casting. Although carbon had been used previously both as a variable resistance in electric circuits and as a resistance heater for furnaces, this is believed to be the first successful and continuous application. The resistors are segmented, certainly a novel idea! A reducing atmosphere prevents chemical deterioration, and the resistors are not subject to mechanical damage because the individual segments are supported on hangers allowing free expansion, contraction and warpage of the furnace walls. The joints between the segments are designed to allow movement while continuously maintaining sufficient area in the contacts to carry the current without arcing. Thus stresses cannot build up in the graphite and cause fracture. Both the resistors and the linings have been used over long periods without appreciable deterioration.

Poland also used a dense graphite for the dies for the Asarco continuous casting process (Fig. 3). Dies for forming the molten copper into rods, tubes and other shapes are machined from graphite blocks. Similar dies were developed by Eldred and by the Ford Motor Co. for similar processes at about the same time.

In nuclear reactors graphite is used primarily as a moderator, reflector, or fuel-element material. The properties which adapt it to such parts are low thermal-neutron-absorption cross section, high moderating ratio, high sublimation temperature, good thermal conductivity, excellent resistance to thermal shock, high strength, and resistance to creep at very high temperatures. Graphite was used as a moderator in the first nuclear reactor built at the University of Chicago, primarily because graphite containing next to zero in elements which absorb neutrons was readily available in sufficient amount. One or two other materials have since been adopted as moderators for specialized reactors but graphite is still used in reactors for low-temperature operation – and especially those for the manufacture of plutonium – because of the relatively low cost of the pure material and the ease and low cost of machining it to precise contours. In reactors to operate at unusuually high temperature, its most important use will probably be as a mixture with uranium isotopes to form fuel elements.

Conclusion

The foregoing discussion shows the wide variety of applications, present and possible, of carbon and graphite in the metallurgical industry. Undoubtedly there are many others which have received relatively little notice and it is hoped that this brief article may stimulate their development and disclosure.

Atoms for Peace*

[Late in 1953, President Eisenhower proposed to the United Nations† that all Governments, including the Soviet Union, contribute uranium and fissionable materials from their stocks to a United Nations' agency to devise methods whereby it could serve the peaceful pursuits of mankind. The invitation to participate was rejected by the Soviet Union unless the project would be chained to a disarmament plan.]

The desire of the United States is that what we do shall remain within the area of the feasible and the do-able and not become hampered by unending arguments or insuperable vetoes.

The United States therefore proceeded with conversations with other states which have either developed raw materials or atomic energy programs, namely, the United Kingdom, France, Canada, Australia, Belgium, Union of South Africa, and Portugal. Secretary of State Dulles later said to this United Nations Assembly:

"The United States is proposing first the creation of an International Agency which will start its work as early as next year; second, an international scientific conference early in 1955 to consider this whole vast subject: third, the opening early in 1955 in the United States of a reactor training school for students from abroad; and fourth, an invitation to medical and surgical experts from abroad to work in our cancer hospitals."

Where We Stand Today — Before we probe the future of international cooperation in this field, let us see where we stand today [in peaceful uses of the atom].

From Oak Ridge in the past eight years nearly 50,000 shipments of isotopes have been sent out to factories, laboratories, hospitals and universities (including 2800 to 50 countries abroad) for experiments aimed to kill cancerous cells, to preserve food, and to speed genetic mutations from which better agricultural strains may be derived.

Likewise the uses of isotopes as tracers are already multitudinous and in theory are without limit — for instance, to measure thickness or soundness of opaque bodies, to show how fertilizers are absorbed by plants, or food or medicine by animals or humans, or trace migration of disease-bearing flies.

[Then there is atomic power from which] new industries can enrich the lives of millions of people.

The complexity of the atomic power reactor calls for expert knowledge; therefore small reactors should be built in many parts of the world. They can be built in a year for well under $500,000. They will train a new generation of atomic scientists, engineers and technicians in nuclear techniques.

Next Steps Forward — We believe that the International Agency should encourage world-wide research; arrange for the necessary nuclear materials, including the eventual production of power; and foster the interchange of information on peaceful uses. Pending the creation of the Agency, the United States is prepared to carry out several steps in 1955:

We are prepared to establish a reactor training school for 30 to 50 scientists and engineers from overseas to study atomic power theory and the applications. Initially the information available will be non-secret, but as the United States and other countries conclude the requisite agreements, additional information will be made available.

Special training courses in radiation safety and medicine will be open to all other nations: Namely, a one to two-year course in American universities on industrial medicine; another on industrial hygiene; and the third on radiological physics to be given at Brookhaven National Laboratory.

Third in our training program comes the vast field of atomic biology and medicine. The Argonne Cancer Hospital at the University of Chicago, the Brookhaven National Laboratory, and the Cancer Research Hospital at the Oak Ridge Institute of Nuclear Studies will be open for one to two-year courses for five to ten foreign students per course. We are also prepared to invite as many as 150 competent visitors from overseas to visit our cancer research facilities during 1955.

Fourth, in the field of tracer techniques the U.S. Atomic Energy Commission will establish special short courses for foreign technicians.

In all instances the limitation on numbers is being imposed simply by our ability to absorb the observers, students and trainees within our present facilities.

Finally, I have just been authorized by the President of the United States to state that the Atomic Energy Commission has allocated 100 kg. of fissionable material to serve as fuel in the experimental atomic reactors to which the Secretary of State and I have previously referred and which are to be situated in a considerable number of places throughout the world.

Ten Complete Libraries — Closely allied to this training program is written information. The United States is prepared to make available in 1955 to the International Agency ten complete libraries of our own material, including complete sets of over 200,000 index cards, our journals of the past seven years, which have abstracted 50,000 scientific and technical books and reports published in all countries, and the original documents already published or declassified [by the U.S. Atomic Energy Commission consisting of] more than 10,000 papers comprising more than 200,000 pages of data.

Furthermore, we will add to all of these libraries

*Verbatim extracts from statements by Henry Cabot Lodge, U.S. Delegate to the United Nations, on Nov. 5 and Nov. 15, 1954.

†See *Metal Progress*, February 1954, p. 81.

‡Many articles in *Metal Progress* have considered various aspects of the power program.

as the material is published, asking only in return that the cooperating nations provide their collections of official non-secret papers, not available in the general scientific literature, to be placed in the appropriate libraries in the United States.

* * * *

Typical Research Reactor — [In an address in Chicago on Dec. 3 by Lewis L. Strauss, Chairman of the U.S. Atomic Energy Commission, some information was given about what can be done with 100 kg. of fissionable material. He said:]

"The fissionable material will *not* be of weapons grade. It *will* be in a form particularly suitable for peaceful application.

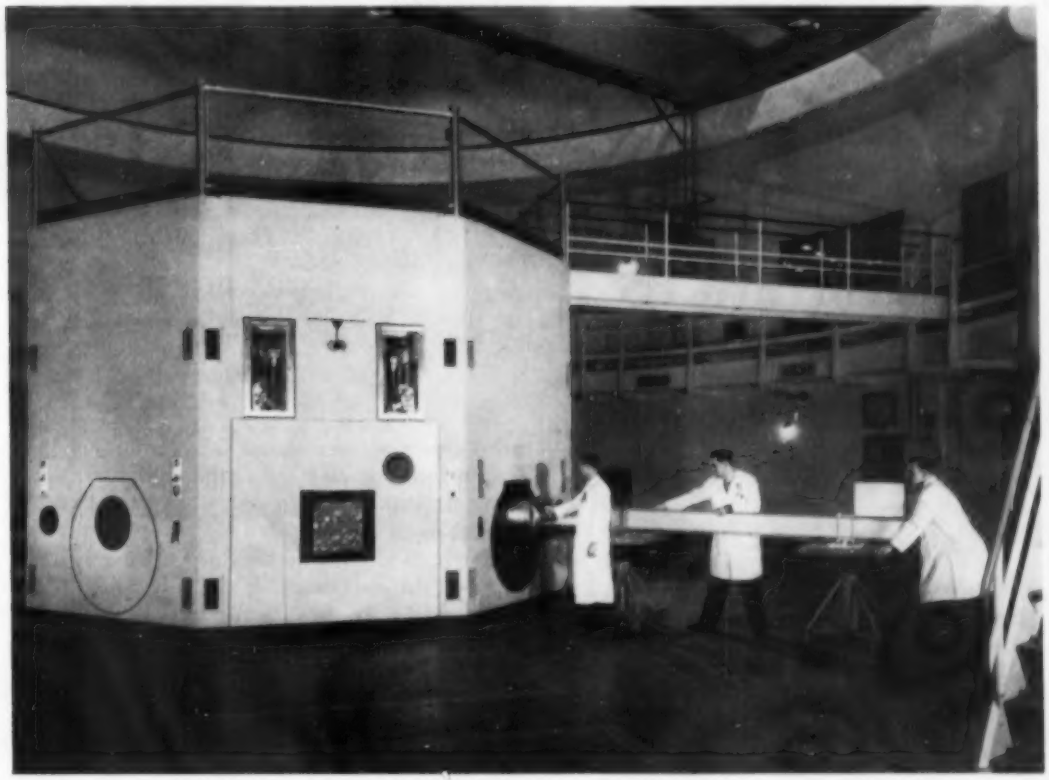
"One of the best examples would be as fuel for research reactors, such as the 'CP-5', code name for Chicago Pile No. 5 at the Argonne Laboratory [shown in the photograph below]. The Commission has removed the security restrictions which have surrounded it. Pertinent information concerning its construction and operation will now be available.

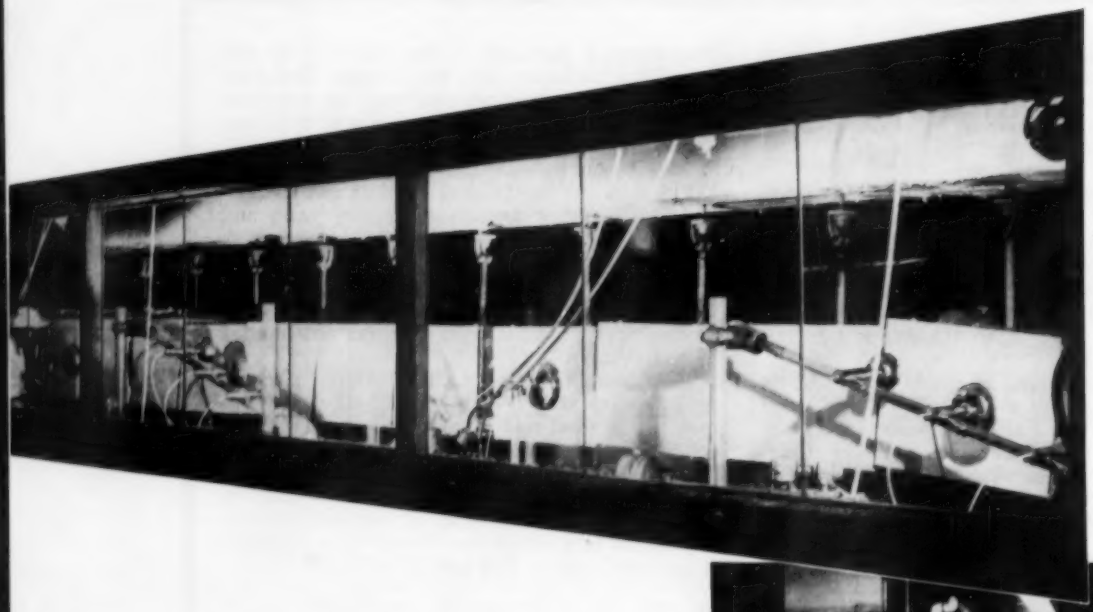
"This research reactor is fueled with aluminum-clad uranium, enriched in the isotope 235, and cooled and moderated with heavy water. This combination permits a high neutron flux — an important feature of a research reactor — at a modest rate of fuel consumption.

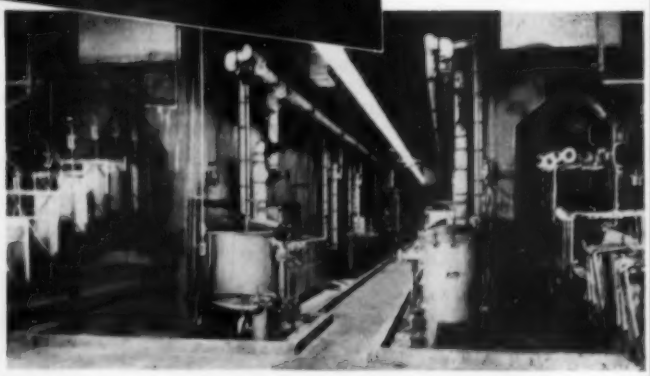
"Our people estimate that 100 kg. of uranium-235 is sufficient for 15 such reactors and to keep them in operation approximately five years and still have almost two thirds of the fuel unconsumed. These 15 reactors would multiply many times the research capabilities of the free world, excluding the United States. Each of them could produce more radioisotopes of varied types than are now needed by any country.

"Lest you think that such a versatile piece of equipment as the CP-5 reactor is fabulously expensive, the total cost (exclusive of fuel and moderator) for the reactor, the reactor building, and the associated laboratories is $2,250,000 and might be considerably less in countries where construction costs are lower. Some types of research reactors may indeed be built for sums measured in hundreds of thousands rather than millions of dollars."

Chicago Pile No. 5 Resembles a Concrete Prism, Eight-Sided, 20 Ft. Wide, 14 Ft. High. Technicians are replacing one of the 50 shielded plugs leading to passages into the regions of high neutron activity. Control room is behind wall at upper right. Photo courtesy of Argonne National Laboratory



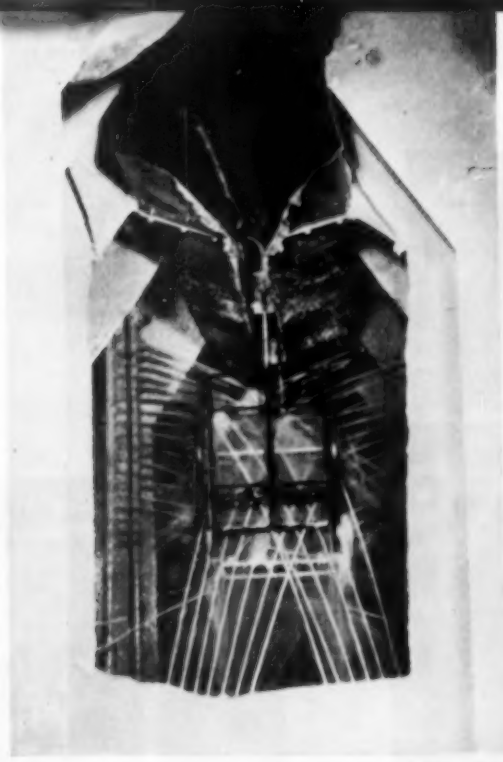


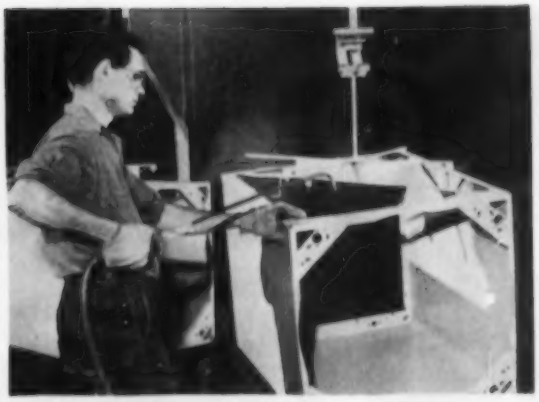


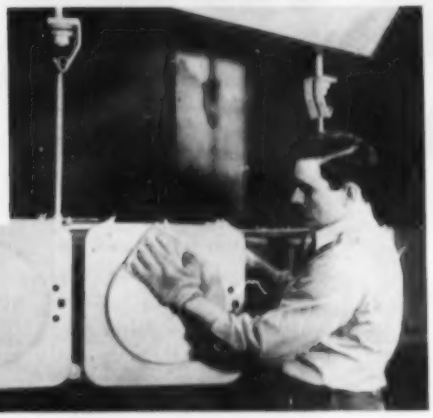
Electrostatic Finishing of Appliances

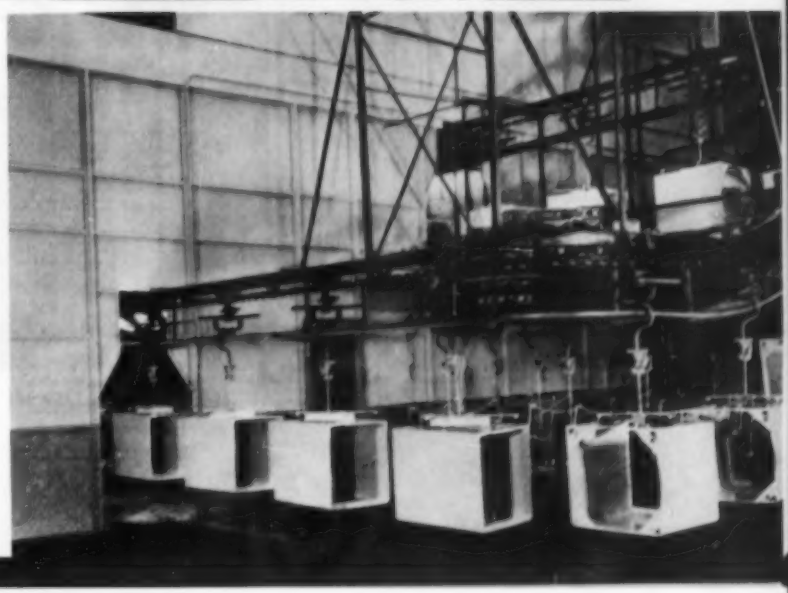
THREE benefits have been realized by General Electric Co. at its Louisville, Ky., plant by installing mechanized lines for electrostatic spray-painting of domestic laundry cabinets and cabinet parts: increased production, improved quality and reduced cost of finishing. The electrostatic spray system (made by Ransburg Electro-Coating Corp.) finishes 79% more surface for each gallon of paint than the former hand-spray method and covers the work with a highly uniform thickness (1½ mils) of paint. Mechanization (by Mechanical Handling Systems, Inc.) has eliminated unnecessary handling and need for storage banks between process steps, and has speeded movement of material through the shop.

This pictorial shows some of the finishing operations on parts which are spray-painted white (the black paint is flow-coated). The view at the top of the page through the windows of the spray room shows the electrostatic spray heads and the work moved by overhead conveyers. A similar number of heads is located on the other side of the conveyer line and at a lower level to coat bottom surfaces of cabinets. Above, right, is the Bonderizing department (Parker Rust Proof Co. process) where the parts are cleaned, rinsed twice, phosphate coated, rinsed, chromated and rinsed finally in de-ionized water.



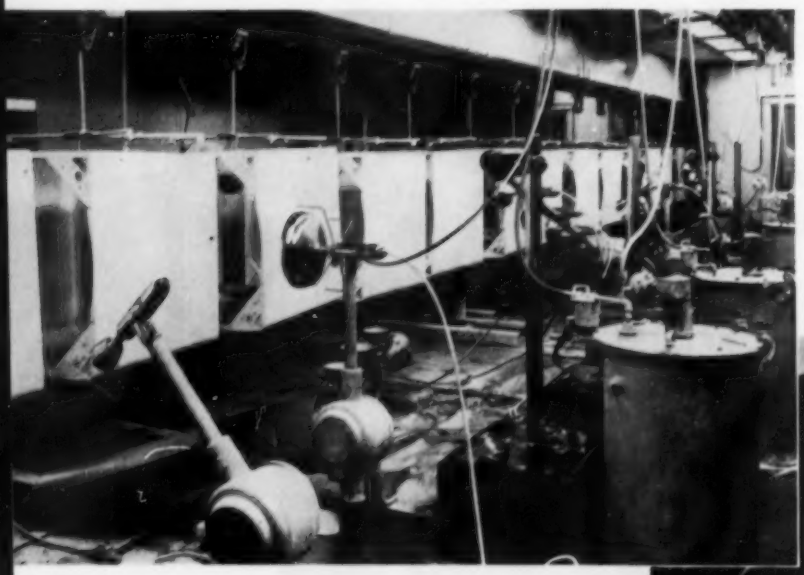


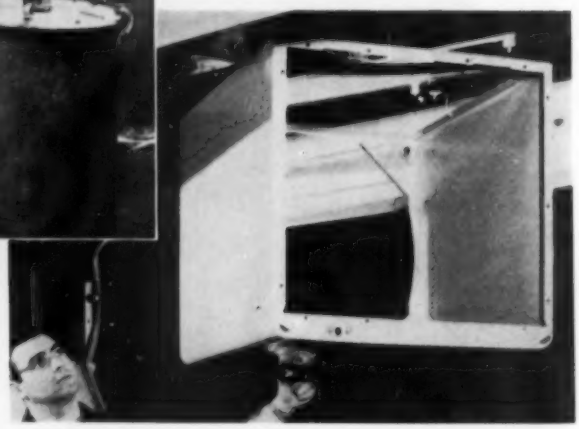




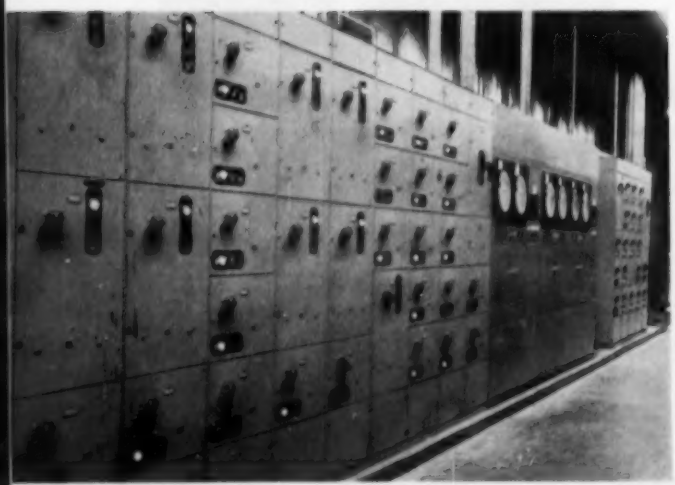
After a 5-min. dry off in a tunnel at 300° F., work moves through a 30-min. cooling loop before being flow-coated with primer paint (above), and then goes through a drip tunnel.

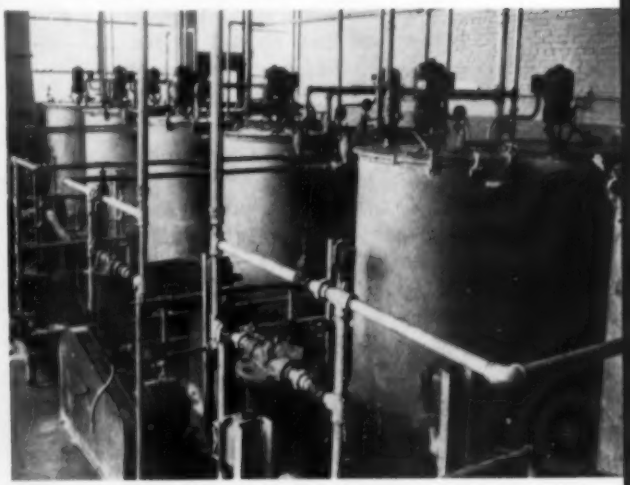
After the prime coat has been baked and then sanded to remove small defects, dust is blown off (top right) and the outside surfaces get a "tack-rag" treatment (next view) to remove all traces of dust. The parts then go into a water-wash spray booth where irregular-shaped sections and bracings receive a reinforcing coat (third photo, right) prior to their entry into the electrostatic spray room (bottom right). The lower view also shows the parts coming out of the finish oven located at a higher level.





In the electrostatic spray line (above, left) the 1½-mil finish coat is applied in a double pass with a 1-min. flash-off between. The finish is baked for 36 min at 320° F., and work goes to inspection (right). "Central operations" are shown in the two lower illustrations: At left is the electrical control panel (made by General Electric Co.) for the equipment for both the black and white paint system; at right is a view of the paint mixing and circulating tanks and pumps.





Germanium and Silicon for Electronic Devices

*By ANTHONY S. RUGARE**

Crystals of precise and minute impurity for rugged miniature electronic devices are at present made more easily of germanium than of silicon, but silicon can operate at higher temperatures. Germanium is more efficient at high frequencies.

SINCE THE announcement of its invention in 1948, the transistor has gone through its growing pains and is now at the engineer's door, ready to open its bag of tricks. It promises to revolutionize such electronic equipment as computers, television sets and radios by replacing the larger and less efficient vacuum tube. Not satisfied with the transistor, the scientists of this atomic age have brought forth still more devices which the popular press immediately dubs "miracles". Early in 1954 came the invention of the solar battery — a device which converts light into electric current. Up till then, the photocell was the best means for converting sunlight directly into power, power enough to operate the needle on a light meter, for example. The photocell has an efficiency of about 1%, but the solar battery boasted an efficiency six times greater. Also early last year an "atomic battery" was announced with some fanfare; it is essentially a broad-area diode in contact with radioactive strontium-90 (a product of an atomic reactor) and is a weak battery of abnormally long life.

Both the solar battery and atomic battery utilize silicon, an important semiconductor.† Neither of these devices enjoys the popularity or state of development of the transistor. For example, it has been estimated that to give the owner of a small home a normal amount of

Table I — A Few Properties

	SILICON	GERMANIUM
Appearance	Dark metallic	Bright metallic
Atomic weight	28.06	72.60
Crystal lattice	Diamond cubic	Diamond cubic
Density	2.4 g. per cc.	5.35 g. per cc.
Melting point	1420° C. (2590° F.)	940° C. (1725° F.)
Boiling point	2600° C. (4700° F.)	2700° C. (4900° F.)
Hardness, Moh's scale	7	6 to 6½

*Metals Engineering, Electronics Div., General Electric Co., Clyde, N.Y.

†EDITOR'S NOTE—Many of the terms used in this article which may be unfamiliar to the reader are explained in Mr. Rugare's former article "The Metal Germanium and Its Use in the Electronics Industry", August 1952, p. 97.

energy for lighting and electric appliances one would need a silicon-surfaced roof covering a quarter acre or more if the electricity were secured direct from the sun's rays. On the other hand, the transistor has already been commercially proved by its use in tiny hearing aids. General Electric's "diffused junction and rate-grown processes" have materially helped the transistor into mass production, and it is now ready to make its long-awaited assault on the electronics industry. Germanium was the first semiconductor used to make transistors, although recently – because of some special properties – silicon promises to hold an important place in the further development of this device.

Of special interest to the metallurgist are the new methods, devices and applications which have been opened up to him by the discovery of the transistor. The very nerve center of the device, whether it be germanium or silicon, demands the special skills of a metallurgist to produce a high-purity material successfully, uniformly and in sufficient quantity. He must reduce, refine and produce single crystals which can be cut up into thousands of tiny pellets. The metallurgist, closely allied with the physicist and the electronics engineer, is rapidly changing the metallurgy of germanium and silicon from an art into a science.

For those who merely look at the physical properties listed in Table I and are not engaged in the field of semiconductors, the transistor must seem to be a dark mystery, and the publicity given to it may appear even more perplexing. The transistor is a three-element control device which utilizes a small current to control a larger one. Unlike vacuum tubes, they require no heated filament and usually will operate with as little as one millionth the power of the vacuum tube doing the same job! Likewise, the transistor is extremely small. Its tiny size, combined with its high efficiency and durability, results in a very desirable item which leads to rugged, miniature electronic equipment.

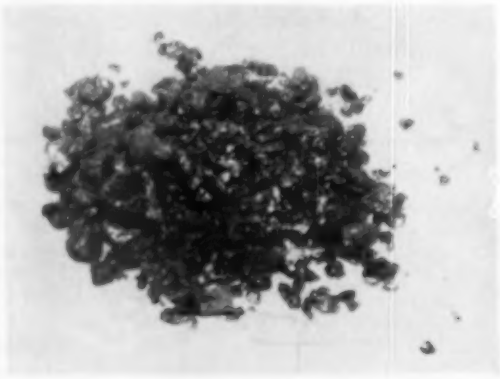
The heart of the transistor is a semiconductor – that is to say, a material which has electrical properties intermediate between those of insulators and metals. Unlike a metal, which conducts electricity because it contains a large number of free or mobile valence electrons, and unlike an insulator, which is unable to conduct electricity because virtually all its valence electrons are strongly tied up in interatomic bonds, a semiconductor has valence electrons which form rather easily broken interatomic bonds and consequently conducts *some* electricity at room temperature. These valence electrons of a semiconductor can be freed to a greater degree by thermal agitation. Still a better method for causing electrical conduction to occur in a semiconductor is to introduce an "imperfection" in the electronic structure. This is easily accomplished by adding a tiny amount of a selected impurity.

For example, the introduction of an impurity such as arsenic into pure germanium or silicon leads to important changes. It enters the crystalline lattice substitutionally – that is, an atom of arsenic replaces an atom of the germanium (or silicon) in its normal position. Because only four of the five valence electrons possessed by arsenic can link up with the four valence electrons of the germanium (or silicon), one electron is left to roam through the lattice, and is available to conduct electricity. In the semiconductor, this is called "n-type conduction".

If the impurity had been an element like indium with three valence electrons, then a situation would arise where the impurity atom is unable to complete the balanced system of valence bonds surrounding the normal germanium or silicon atom. An electron deficiency or a "hole" would occur. Whenever an electron from an adjacent bond would attempt to fill such a hole, it would leave a hole behind – the "hole" would appear to wander away to the bond which just gave up one of its electrons. Again a situation arises which favors electrical conduction. In this case the semiconductor is the "p-type", since the holes behave as positively charged particles.

Very often p-type and n-type impurities will exist simultaneously in germanium or silicon, and the type of conductivity is then determined by the excess of one over the other.

Fig. 1 – Silicon Needles Prior to Pre-Melting. Photograph about half size



Although impurities are necessary for electrical conduction, their presence must be rigorously controlled. In transistors an excess of one atom of impurity in 10,000,000 seriously impairs the yield of certain electronic devices. It is only by the careful preparation of the semiconductor materials that things such as transistors, diodes, solar batteries or atomic batteries can be made.

So far in this article, germanium and silicon have been referred to as the important semiconductors. Germanium has already found wide application in the transistor and the diode. Recently silicon has come to the fore as a serious challenger for germanium's leadership in the semiconductor field. As mentioned earlier, it has been glamorized by such items as solar batteries and atomic batteries, but it has actually found a sturdier and more reliable home in the transistor and diode.

As with most things, germanium and silicon both have their advantages and disadvantages. An idea of what the future holds in store may be secured by comparing their occurrence, properties, and processing techniques and problems.

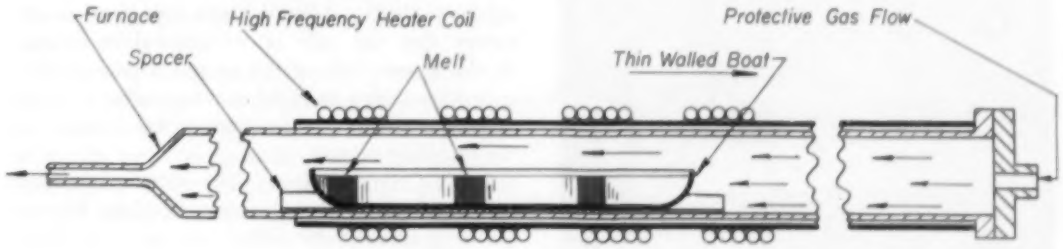
Availability – A choice between germanium and silicon solely on the basis of their occurrence in nature would eliminate germanium completely. Silicon is the second most plentiful element in nature. It always occurs in the combined state – in fact the silicates are the major constituents of most of the important rocks. Germanium, on the other hand, occurs only in traces – although it is found in nearly every mineral. There is no known rich source. The chief American supply comes as a byproduct of the zinc smelting operations in the tristate area of Missouri, Kansas and Oklahoma. The zinc ore mined in this area contains from 0.01 to 0.10% germanium. In England, flue dusts from producer gas plants have been found analyzing 0.50 to 0.75%. One need only to compare these figures with the fact that silicon constitutes about 26% of the whole earth's crust, oceans and atmosphere to realize the disparity. Still germanium is believed plentiful enough for any electronic requirements, since so little goes so far.

Extraction – Both silicon and germanium require rather extensive and careful chemical processes for their extraction. Silicon is normally available in the form of needle-like crystals of metal (Fig. 1) containing a few parts per million of impurities. Germanium, however, comes as germanium dioxide, a white powder "better-than-spectrographically" pure. This is later reduced to a metal powder in a hydrogen atmosphere at 1200° F. (650° C.). This powder is then melted at 1750° F. (950° C.) in a hydrogen or inert atmosphere to a very brittle grayish white metal having about one part impurity in 10,000,000.

Processing – Thus, of the two metals, silicon is considerably less pure, and at this point the technology favors germanium. During the past few years intensive research and applied engineering have resulted in almost routine processing techniques for making large germanium crystals of desired purity. Processing of high-purity silicon presents other difficult problems. In fact, we do not understand its fundamental properties nearly as well as we do germanium's. However, it is to be expected that the chemistry and metallurgy of silicon will soon be brought to the status now enjoyed by germanium.

Basically, their processing is similar. Both are brought through purification processes and converted into single crystals. Fundamentally, the purification technique is melting and directional cooling. The principle of the technique may be understood by regarding germanium (or silicon) and its impurity which is to be removed as a binary alloy. The impurity (or impurities) may either raise or lower the freezing point of the molten alloy. If an ingot of the alloy is melted and then frozen slowly, starting at one end and progressing to the other, the impurities will segregate, being swept to the last region to freeze if they are such as to lower the freezing point. On the other hand, if the impurity or impurities tend

Fig. 2 – Cross-Sectional Sketch of Zone Refining, Showing How Metal Is Repeatedly Melted in Transit Along the Furnace



to raise the freezing point, they will be concentrated in the first region to freeze.

This process of purification by directional cooling is known as fractional or progressive crystallization. It has been replaced by a more effective process known as "zone refining".

Zone refining differs from fractional crystallization in this way: Rather than melting an entire ingot only a small zone about 1½ in. wide is melted. This small melted zone traverses the entire length of the ingot. As sketched in Fig. 2, the heating medium is induced electric currents and by arranging coils in multiple, one ahead of another in the zone-refining furnace, several molten zones can be made to traverse the charge simultaneously. Thus, if six coils are passed along the ingot, then each segment is melted and frozen six times. As in fractional crystallization, impurities are swept to one end of the ingot, but the resulting purification is about four times as effective.

Germanium can easily be zoned-refined as it comes from the reduction process. Silicon, supplied in the form of small needle-like crystals, is more effectively zone-refined if it is first cast into a solid ingot. This process is known as premelting.

Fig. 3 – Germanium Single Crystal in Furnace

Most of the impurities in both germanium and silicon segregate into the liquid phase (rather than into the solid phase). Zone refining of both materials tends to produce almost intrinsic (pure) material. The zone-refined billets are evaluated and selected portions are made ready for conversion into a single crystal.

Crystallization – Single crystals of germanium and silicon are prepared by an adaptation of the Czochralski method known to practitioners as "pulling", and shown in Fig. 3. The germanium or silicon is melted in a suitable container and a small seed of single-crystal materials is dipped into the melt. While maintaining the temperature of the melt only a few degrees above the melting point, the seed is slowly withdrawn, pulling with it a rod of liquid. At a finite distance above the surface of the melt, the rod of liquid reaches the temperature of recrystallization and from then on solidifies as a single crystal. The size of the crystal can be controlled by varying the temperature and pulling rate. The faster the pulling, the smaller the diameter. The hotter the melt, the smaller the diameter. The success of a single-crystal pulling process depends largely on the careful control of pulling rates, temperature, vibration conditions, preparation of the charge, and furnace environment.

Production of single-crystal germanium is a matter of routine. Crystals having a relatively high degree of lattice perfection are common. By the addition of controlled amounts of impurities such as antimony, crystals of any desired degree of imperfection can be produced. A key factor in the development of transistors and diodes has been the ever-increasing perfection of germanium single crystals.

N-type germanium single crystals have long been used. More recently the "rate-grown single crystal" has appeared. In its manufacture, pure molten germanium is "doped" with traces of gallium and antimony. The pulling process is similar to that used for pulling n-type germanium except that the rate of withdrawal is varied. As the growth rate of the crystal is periodically varied from slow to rapid, corresponding regions of p-type and n-type conductors are formed in the resulting crystal.

Single-Crystal Silicon – The story of single-crystal silicon is by no means complete. Silicon has been successfully pulled into single crystals,

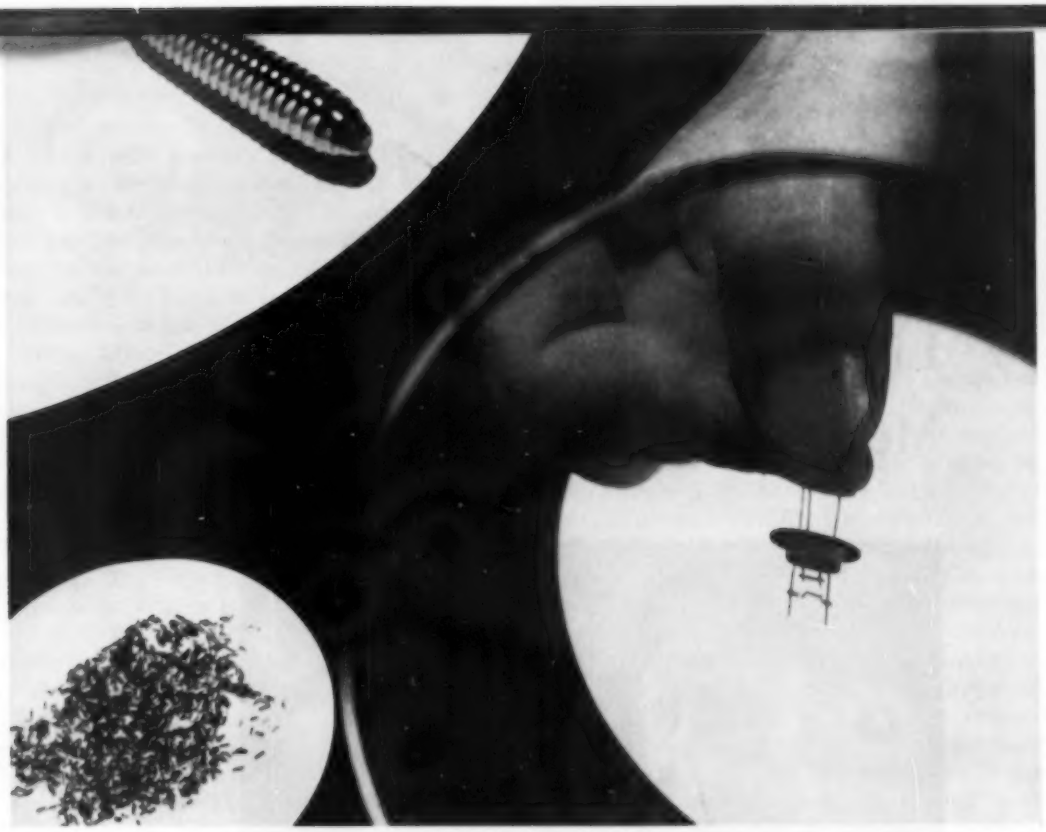


Fig. 4 – Rate-Grown Germanium Ingot at Top Left Is Diced Into Tiny Bars (in Circle at Left), Enough to Make 2000 Transistors Like the One Shown Under the Magnifying Glass

but the problem has been more formidable. Silicon's high melting point and its chemical reactivity limit the choice of a crucible to quartz (whereas both graphite and quartz can handle germanium). More extensive precautions must be taken to prevent contamination of the silicon melt from the heat source. The starting material used for pulling silicon single crystals is not as well under control as is the germanium billet. In general, there are more variables or unknowns connected with the pulling of silicon single crystals, but the variables are steadily and rapidly being brought under control and the unknowns are gradually coming to light. Consequently, it is expected that in a short time silicon will enjoy the same position as germanium in that crystals of predetermined purity and electrical characteristics can be pulled at will on a production basis.

Uses and Limitations – Once a germanium or silicon single crystal of the proper specifications has been produced it is cut up into thin wafers which in turn are processed into thousands of tiny pellets. Using n-type material, p-n junctions are produced by diffusing an impurity into the pellet. (In rate grown crystals this junction already exists.) For a transistor three contacts are very carefully attached to the p-n-p or n-p-n region and after further processing the entire subassembly is put into a hermetically sealed package and evaluated. For diodes only a p-n junction and two leads are necessary. Only after the complete diode or transistor is made can the semiconducting material be best evaluated.

In spite of easy processing, germanium has one major disadvantage compared to silicon. Germanium devices do not exhibit semiconducting characteristics at as high temperatures as silicon. Germanium devices will not generally operate at ambient temperatures much above 100° C., whereas silicon devices will operate at ambients above 200° C. (400° F.) Furthermore, silicon devices possess a much higher back resistance for a given voltage. These are important characteristics to be considered when a component is selected for electronic equipment.

Consequently, it is expected that the consumption of silicon in the electronics industry will show a marked increase in the coming year. Germanium, however, will not pass out of the picture. Its ease of processing, plus the fact that germanium devices are more efficient at high frequencies, insures the continued production of germanium devices.

An Eminent Living Metallurgist

Roy H. Davis
President, Atlas Steels Limited

If anyone interested in toolsteel had been visiting in Welland, Canada, in 1928 he could have seen a small group of old buildings owned by Canadian Atlas Steels. He could have learned that this company had been twice bankrupt and was then in the hands of receivers. Certainly not an attractive business proposition!

Today if one visits Welland he finds Atlas Steels Limited on that same site, a toolsteel plant employing 1500 men, extending over a mile, and housing the most modern production equipment, including a continuous casting machine for stainless steel, a planetary rolling mill, strip and welded tube mill – many items of which have been installed for the first time in North America.

The driving force that has brought about this phenomenal change is embodied in the person of Roy H. Davis, formerly a citizen of the United States and now a staunch Canadian.

The annual report of Atlas Steels Limited for 1952, issued on the occasion of its 25th anniversary, reads like a Horatio Alger story as it describes the company's development year by year. As such it might well be taken as an inspirational booklet for aspiring young men in postgraduate business courses.

It was in 1928 that Roy H. Davis, then 43 years old and a plant manager for a large corporation in the States specializing in alloy steels, visited Welland and saw the potentialities of the little Canadian company. R. H. (this being the friendly name by which he is known to his executives, and by which he will be designated in this profile) returned to the States and persuaded some 20 of his friends to put $10,000 each into the purchase. None of his financial contributors had seen the plant – that was hardly necessary, for (as R. H. told them) "you wouldn't see anything except some old buildings and machinery; I'm not asking you to invest in *them*, I'm asking you to invest in what the company *can become*."

With this limited capital, R. H. proceeded to some essential improvements. Electric annealing furnaces replaced obsolete coal-fired ones, operations were rearranged and production lines straightened. This took some five months – during which time, however, salable goods were produced by the 35 people then on the payroll. The profit, for profit there was, amounted to $3517 and was promptly put back into the business – a policy that has been continued in large measure throughout later years.

Then came the Wall Street crash of 1929, but this young company faced the rough waters and swam through to a profit. Even in the years of financial depression Atlas Steels Limited has always been in the black, in no small measure due to the courage and leadership of young Davis, the company's then and present president.

In 1951 R. H. had decided that it was time to install a new strip mill to expand the stainless steel division, recently created. Sale of securities raised $8,000,000 – a good measure of the public's confidence in the management and in the expanding economy of Canada. Another four million had been put into the project from earnings, $12,000,000 in all, and quite a figure in comparison with the $200,000 of initial capital!

A visitor to the Welland plant today is impressed with the good housekeeping throughout, and the complete safety-first measures. Generous space is provided for runways and working areas around all machines. When he chats with foremen and departmental managers he absorbs the impression that R. H. is both liked and respected by all, and for very good reason. The phenomenal expansion of a quarter-century could not have been the result of slave driving. Rather it has been accomplished by R. H.'s friendship with the steelworkers, backed by his ability to recognize and secure qualified young men to head the numerous divisions such as production, maintenance, sales, advertising, finance, public relations, and research.

So much for the history of the company. What of the man behind the scenes?

Roy H. Davis was born in 1885 in the tiny village of Amity in the mountains of northwestern Oregon. While still at high school he decided he wanted to enter the Annapolis Naval Academy. So he worked summers in a gold mine as a laborer to get some necessary money. He set about the project in a quite characteristic manner. In those days each senator recommended a prospective student and an alternate. R. H. was the alternate, so he proceeded from Oregon to Washington by freight train and day coach, and was on the spot for the alternate's chances. He still remembers that his mother sewed into his undershirt the $20 gold pieces necessary for the trip and his modest spending money. By 1909 Annapolis had trained him well in engineering, both mechanical and electrical.

You will learn from his executive associates that R. H. has a gracious lady as his wife, a son who just now is attending the International Labor Conference in Switzerland, and three daughters. In the field of sport, R. H. has been a keen oarsman, and is a golfer and a fly-caster of no mean repute. He enjoys horseback riding and thinks it

is one of the best means of keeping in trim. Among his other interests has been dairy farming, but this has given place to the raising of beef cattle at his place at Fonthill, near Welland.

A few quotations from remarks made to the writer as he wandered through the Welland plant will serve to highlight the character of the president of Atlas Steels Limited.

One workman supplied the friendly nickname by which R. H. is known among his employees, namely "the Great White Father" – this from one who was working in the plant before it was taken over by the new management and who, after 27 years, evidently held R. H. in the highest esteem. Another remembered that in the early days if he was pushing a heavy load of steel on a truck – at that time there were not so many overhead cranes – he might easily find R. H. with his coat off, helping. Satisfactory employer-employee relationship is proved by the fact that there has never been a stoppage of work in Atlas Steels Limited. One of the metallurgists, a Canadian, recalls that when he was working in the States, he was approached by R. H. who said "We would like you to come up to Canada and help us." It struck him as typical of the man's attitude, instead of saying, "I'm offering you a job."

Two or three times a year Mr. Davis speaks to each group of men in the various shifts, and gives them a clear picture of the state of the company as to new plant that is to be installed, the profit the company is making, and such other items of interest. In these talks the personal pronoun is never heard. The day the writer visited R. H. he had already been at the plant since 7:30 in the morning to see a group of men on the early shift before they started work.

Perhaps enough has been said to indicate that in Roy H. Davis American metallurgy can be proud – both the United States for his early successes, and Canada for the achievements of her adopted son. The Welland operation is small enough so a wholesome personal relationship between president and managers and foremen and workmen can be maintained. Back this with a president having sound engineering and business acumen and you have an unusually good combination. Of him Emerson might rightly say:

"Then there are the workingmen on whom the burden of business falls, those who love work and love to see it rightly done, who finish their task for its own sake – and the State and the World is happy that has most of such finishers."

HAROLD J. ROAST

Book Review...

Stainless Steel Classic Reissued *Reviewed by A. L. FEILD**

STAINLESS IRON AND STEEL, by J. H. G. Monypenny, Chapman & Hall, Ltd., London. VOL. I – STAINLESS STEELS IN INDUSTRY, 1951, 524 p., 45s; VOL. II – MICROSTRUCTURE AND CONSTITUTION, 1954, 330 p., 55s.

HERE is a greatly expanded edition in two volumes of the well-known and popular publication which first appeared in 1926. To your reviewer's knowledge Monypenny not only was the first one to write a book on stainless steel, but continued thereafter to a greater degree than any other such author in the devoted pursuit of his chosen profession of metallurgist and research worker. Long continuity of effort combined with conspicuous intellectual honesty and scholarship gives to Monypenny and his works a very special place in the unfolding history of stainless steel.

These two volumes are an essential part of

J. H. G. Monypenny

the metallurgical library of the research metallurgist and the scientist. In fact, the two previous editions remain of importance, particularly for many interesting observations on the growth of our understanding – some of which have been omitted from this latest work.

Volume I on "Stainless Steels in Industry" (1951) is quite understandably slanted toward British steelmaking practices and customer's usage. To a considerable extent it is not directly focused on the immediate aims of metallurgical technology in the United States. Nevertheless, the points on which the British and American pictures differ should be in themselves of current interest to all students irrespective of their locale. Most of the footnote references to the literature in Volume I cover a period prior to 1941, although some advances in metallurgical knowledge made as late as 1947 are included.

In Volume II on "Microstructure and Constitution" the derivation of the iron-chromium and the iron-chromium-nickel equilibrium diagrams is painstakingly reviewed both historically and critically, with lucid explanations of the general subject. Also included are chapters in which the effects of the important supplementary alloying elements are discussed.

An interesting chapter is on "Intergranular Corrosion in Austenitic Stainless Steels". Monypenny accepted the chromium depletion theory of intergranular attack only as a working hypothesis, admitting that it explains most but not all observed phenomena. To those who are familiar with the generally prevailing British attitude toward the stabilized chromium-nickel grades it is not surprising to find titanium ranked equal to columbium as a stabilizing element without any qualifying remarks about the effect of titanium on steel quality. However, this remains somewhat disconcerting, as is also Monypenny's predilection for the acid copper sulphate test and his skepticism regarding the realistic value of the boiling nitric acid test. Nevertheless, this new volume is a stimulating and provocative book. The location of literature references at the end of each chapter is an improvement over Vol. I. Except for a couple of references on sigma phase in 1948 and 1949, the bibliographic notations fall in the period ending in 1942.

Monypenny made frequent contributions to metallurgical journals, one of his last being an article on "Stainless Steel for Turbine Blading" published in 1945 in the *Transactions* of the Institute of Marine Engineers. Born in 1885, he became in 1904 chief of the research laboratory, Brown Bayley's Steel Works, Ltd., Sheffield, England, and continued his association with this company until his retirement in 1945. There he was for much of this time a colleague of the distinguished metallurgist and stainless steel inventor, Harry Brearley, works manager.

*Dr. Feild is associate research director, Armco Steel Corp., Baltimore, Md. As is perhaps too well known to repeat, Alex Feild is an American pioneer, making in 1926 stainless steel in a 2-ton electric furnace from high-carbon (4 to 6% C) ferrochrome, and working with this family of alloys ever since.

Stairway to the Future, Featured at a Stainless Steel Industry Exhibit Held in New York to Demonstrate the Versatility of This Metal for a Wide Range of Consumer Products

Salt Bath Hardening of Tools

*By ELMER B. HAUSER**

A case history reporting that the salt bath method has increased output, quality and economy in the heat treatment of high speed toolsteels at Weldon Tool Co.

As MANUFACTURERS of many different metal-cutting tools, varying in analysis from straight carbon and alloy-type carbon to high speed toolsteels, heat treatment is vitally important in our operation. That the heat treatment for a given steel be correct and be easily duplicated is a basic requirement for quality work and steady production. We turned to the salt bath method for hardening tools of many different high speed steels in early 1952. There were three main objectives for doing this: *(a)* to increase production in a limited floor space; *(b)* to harden accurately those high speed steels, such as molybdenum M 1 and M 10 types, which have a tendency to decarburize slightly when hardened in atmosphere-controlled furnaces; *(c)* to reduce warpage encountered in long tools, and thereby reduce straightening time.

We realized all of these primary objectives and several additional advantages. In particular, we can use our four salt bath furnaces for several hardening methods that were not contemplated originally, these being neutral hardening of straight carbon (water quenching) and alloy (oil quenching) toolsteels, martempering parts made of S.A.E. 52100 and hardening Type 400 stainless steel pins.

Our standard metal cutting tools are end mills which are primarily of the straight shank type (shown in Fig. 1), reamers, broaches, counterbores, circular form tools, form-relieved cutters as well as special types of milling cutters. The high speed steels are either tungsten-base (A.I.S.I.-S.A.E. Types T 1, T 2, T 3, T 5 and T 15), molybdenum-base (M 1, M 2, M 3, M 5, M 10, or cobalt grades. The carbon toolsteels are of the water, oil, and air hardening types. Also, we are currently hardening other steels, including stainless, which is used for aircraft components. The variety of the latter is such that very seldom do two finished lots of parts have the same final hardness.

The weight of the workpieces ranges from 2 oz. to 20 lb. and therefore the quantity of work treated each hour will vary. Also the flow of work depends on the adaptability of the fixtures for the work being treated.

The decision to install a salt bath line was made after various methods for heat treating high speed steels had been investigated and the excellent results obtained with test pieces convinced us of the advantages of electrode-heated

* Metallurgist, Weldon Tool Co., Cleveland.

Table I — Dimensions and Electrical Rating of Salt Bath Furnaces

FURNACE APPLICATION	CONNECTED LOAD RATING	WORKING DIMENSIONS*	OPERATING TEMP., MAX.	FLOOR SPACE†
Preheat	30 kw.	15 × 11 × 24 in.	1250° F.	46 × 90 in.
Preheat	30	15 × 11 × 24	1600	46 × 90
High Heat	70	15 × 11 × 24	2350	46 × 90
Quench	25	24 × 15 × 24	1300	43 × 84

*Length by width by salt depth. †Includes transformer.

Fig. 1—Line of Electric Salt Bath Furnaces at the Weldon Tool Co., Cleveland, Used for Hardening Carbon, Alloy and High Speed Steels. Operator is removing a load of end mills from high-temperature bath. Furnace at the right is for quenching. Holding fixtures and loads are transferred by overhead rail

salt baths. Accordingly, four such furnaces (made by Ajax Electric Co.), of the size and capacity noted in Table I, were installed in late 1951.

The basic pattern for hardening any of our high speed tools is to heat the tools in two successive preheating furnaces, austenitize them for a short time in the high heat furnace and quench in the fourth furnace. These treatments are followed by an air cool, wash, rinse, and then a temper treatment (in a Leeds & Northrup Hump furnace). Times and temperatures for each operation in hardening high speed steel pieces, or neutral hardening or martempering vary with the size and analysis of the piece. Some idea of the time required for salt bath heating can be derived from these examples: A ⅜-in. round of high speed steel is heated to 2200° F. in 1½ min. in the high heat bath. (A controlled atmosphere furnace used previously required twice that time.) A ¾-in. round of oil hardening toolsteel is austenitized at 1480° F. in only 7 min. (In an atmosphere furnace the time was three times as long.)

Our nitriding procedure for the cutting faces of high steel tools produces a uniform case depth which can be easily varied from 0.0002 to 0.0015 in., depending on the duration of treatment. A sodium-potassium cyanide mixture of our own formula is employed.

The benefits we have obtained from our salt bath furnaces are more than the increased output from the heat treating department, reduced warpage, and versatility already mentioned. These additional benefits are as follows:

Increased Production – The volume of work from the heat treating department has been increased at least 100%. We heat treat 300 to 350 lb. of tools on this line per hour, which is approximately twice the amount of work put through the two lines of controlled-atmosphere furnaces used formerly. Also there is less handling time in the initial steps of heat treatment because more pieces can be loaded on each fixture (traveling on an overhead rail) and less variation in the temperature of the bath when it is loaded.

Better Quality – Because long tools can now be heat treated in a vertical position instead of on a horizontal hearth as was necessary formerly, warpage and breakage during straightening have been reduced. In addition there is no loss in size since the corrosive effect is practically absent and the gain in size resulting from the formation

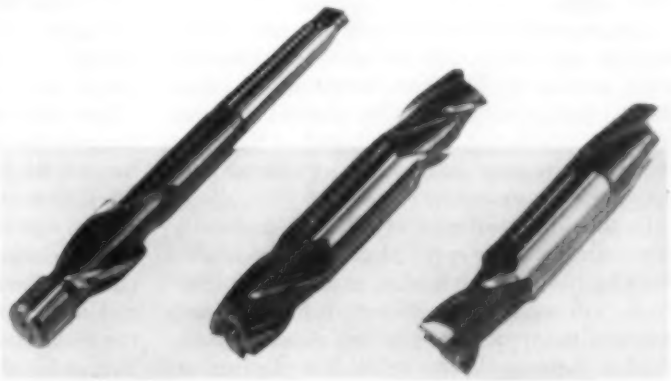
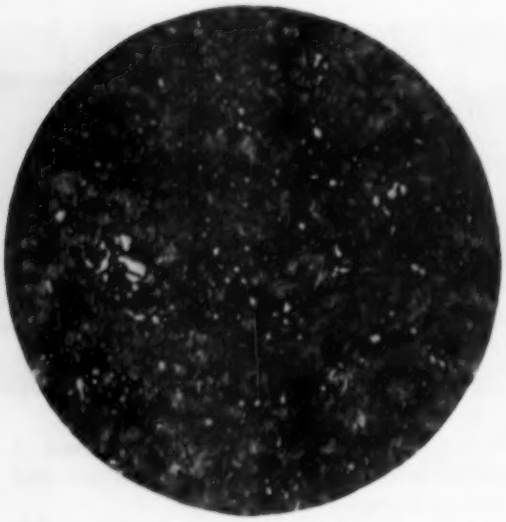


Fig. 2 – "Tu-Lip" Counterbore, 4-Flute Double-End and 2-Flute Double-End Mill are Typical Examples of the Cutting Tools Made by Weldon Tool Co.



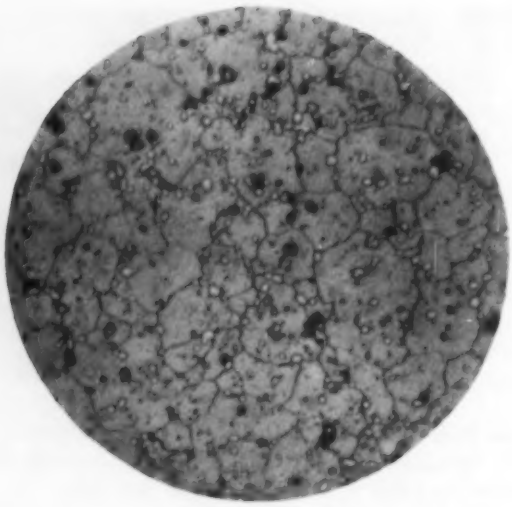


Fig. 3 – Microstructure Produced in ⅝-in. Double-End Mills of Molybdenum-Tungsten High Speed Steel (0.82 C, 0.26 Mn, 5.12 Mo, 6.33 W, 4.12 Cr and 1.91 V). Etched in 4% Nital, 1000 ×. Left–Structure of hardened alloy after quenching in bath at 1125° F. from 2210° F. Grain size is 17 as measured by intercept method, carbides in solution, and hardness is Rockwell C-66.8. Right – After tempering at 1040° F. the structure is fine-grained martensite having the required hardness (Rockwell C-65.9) and toughness for optimum cutting properties

of an oxide surface layer is negligible. The amount of change due to the latter was found to be from 0.0002 to 0.0005 in. as measured on the diameter of 0.388-in. test pieces after final heat treatment.

Versatility – The four Ajax furnaces are being used for the hardening of high speed straight carbon and alloy toolsteels, stainless steels, and for martempering.

Economy – We estimate an over-all savings of approximately 0.005¢ for each pound of material treated. It is difficult to determine exact savings because, first, we do not divide heat treatment into its various steps; second, the electrical energy is not separately metered from that used in the rest of the plant; third, the cost of the salts used varies.

The important economy is in the heat treatment of high speed tools for which the furnaces were purchased. The heat treatment of other steels (straight carbon or alloy grades) in these furnaces, which was not anticipated at the time this purchase was made, is a significant but nevertheless a secondary economy.

In the heat treatment of all such materials, especially the high speed steels, the use of fixtures for handling the work is essential. The time cycle will vary with different loads, but we estimate an approximate saving of about one-third in the over-all time cycle. The elimination of warpage is a big saving. Hardness of tools is maintained between Rockwell C-64 and 65.

Reproducibility – The data from tests made by our metallurgical department over 2½ years reveal that there has been little variation in hardness and microstructure during this period. For example, the hardness of an M 2 high speed steel after tempering was within the range of Rockwell C-63.8 to 65.0 for the surface on the sides of the test pieces, and within C-64.1 to 65.5 on the ends. We are able to duplicate any previous heat treatment because of our method of control and inspection. Temperature recording and indicating instruments for each bath or furnace are tested daily for accuracy by the potentiometer method. A Rockwell hardness, file-test hardness, fracture test and a metallographic examination are made on each day's run of work. The salt baths are checked periodically by chemical analysis to guard against build-up of oxides.

Less Grinding – Most of the finishing operations on the tools can be done before hardening because the heat treatment does not decarburize, pit, scale nor corrode their surface. Consequently only a minimum amount of stock has to be removed during the finish grinding operation to clean up the cutting edge. Since there is no skin pick-up (oxidation) from the heat treatment, the tools retain a keen cutting edge after final sharpening that wears well in service.

Light Metallurgy . . .

Wonder Metals

By R. P. LISTER

I AM HEARING A lot these days about the Wonder Metal, titanium. Things have changed a lot since my day, of course – since I beat my Brinell tester into a ball point, as it were – but in those far-off days titanium, though indubitably a Wonder Metal, suffered from the disadvantage that a little of it took a lot of getting. Gangs of highly educated and highly paid men, surrounded by dozens of gadgets oozing different kinds of electricity from every corner, would cluster round one tiny furnace for weeks and months on end, persuading the titanium to grow. It grew; but it came dropping slow, like peace from the veils of the evening in W. B. Yeats's poem. Only the titanium did not drop from the veils of the evening, but from a kind of knob in a vacuum. If they got a couple of milligrams of it in a fortnight they were doing well.

It always seems to be so with Wonder Metals. There is always some drawback that the journalists fail to note in those popular articles of theirs, when they are drinking in thirstily what the scientists tell them; or else the scientists, having an axe to grind (as even scientists have from time to time) stress the wonder and soft-pedal the drawbacks when they are talking to the journalists. I do not know what shocking thing goes wrong with titanium, now that there is enough of it for there to be anything wrong with; I am not in the titanium picture. But I am sure there must be a skeleton in the titanium family cupboard somewhere to set off against the sheer wonder of it.

It was so with magnesium, I remember. Now, there was a Wonder Metal, if ever there was one. It was fantastically light and superbly strong, as long as you remembered to compare its strength with its weight; and, what is more, as the scientists informed the journalists on many occasions, it did not burn up with an intense white flame if you put a match to it, as the ignorant public might well (and did) imagine. Not, anyway, if it was thicker than such-and-such a cross-section, and nobody would be such a fool as to use it as thin as that.

It was quite obviously a good thing to make propellers of, in the days when aircraft had propellers. It was frightening to think of all the energy that had been running to waste in huge, heavy aluminum blades whirling round and round. Make them of magnesium, and the world, and the aircraft, could forge ahead. People had even gone to the trouble of measuring the fatigue strength of magnesium, in nicely polished smooth specimens, and it was as high as the engineer's heart could desire.

The only snag was that the fatigue strength stubbornly refused to stay anything like so high if there was any kind of notch in the magnesium. Nobody notched the blades deliberately, and as long as they remained unnotched they were quite good blades. Unfortunately it only took the slightest dent from some minute bit of gravel off the airfield to start a handsome fatigue crack shooting across at almost no stress at all. I myself have examined, exhaustively, scientifically, and quite unnecessarily, several dozen magnesium propeller blades neatly fatigued off anywhere between the hub and the tip, tracing the fatigue crack conclusively to some little tiny hollow near the edge – usually the leading edge, but sometimes the trailing (as if it mattered) – which must in its turn have been caused by some fragment of solid matter no bigger than a largish pinhead impinging lightly on the Wonder Metal in the course of its duty.

Bronze, of course, must have been the first Wonder Metal of all. Only an old Stone Age man, who had spent the first 20 years of his adult life shaving with a bit of jagged flint, could

tell you what a Wonder Metal bronze was. He took to it in a big way, eating with and off it, decking himself with ornaments of it, sticking it into his enemies in a sharpened form, and warding off the attempts of his enemies to stick it into him with big round slabs of it. Such was his devotion to the stuff, he even used it to hack huge masses of stone into shape in order to build pyramids or set up monoliths and megaliths and cromlechs and dolmens and anything else he fancied. Anybody who has tried to hack a bit of stone 20 ft. long and 40 ft. round into a suitable shape for a dolmen or Standing Stone, using only a bronze chisel and a hammer made of a boulder lashed to the end of a wooden handle with leather thongs, will realize what the old Stone Age man must have gone through in order to be able to regard bronze as a Wonder Metal for dolmen construction.

The next Wonder Metal was iron. Only an old Bronze Age man, who had spent the first 20 years of his adult life shaving with a bronze razor, could tell you what a Wonder Metal iron is. The first time he shaved with it he must have realized that all the dreams of sorrowing mankind had come true; the age of peace and glory had set in. Smooth-chinned, he kissed his old Bronze Age wife (who must have enjoyed it for the first time in 20 years of adult life) and set off for the day's hunting with a spear-head that, as he found, would actually go through the skin of a young aurochs without requiring half an hour's straightening and sharpening afterward. When he got home he must have slept happily, leaving his razor and spear-head on the doorstep of his cave, where he used to leave the bronze ones. Only when he awoke and found both razor and spear-head covered with red rust after exposure to the forest dews must he have realized that the days of peace and glory ushered in with the Iron Age had their headaches too. After that there was the nightly wiping-down and greasing with aurochs fat, such as is still practised in wildwood circles; and, after that, the railway, the automatic loom, the internal combustion engine and the Bomb, all of which sometimes lead us to think that the Bronze and even the Stone Ages had their points.

After iron, aluminum; after aluminum, magnesium; and after magnesium, titanium. Wonder Metals they may be, but all have some unwonderful aspect which shocks the public and makes work for the metallurgist.

Then there is the most wonderful Wonder Metal of all, which was a Wonder Metal in the earliest ages and remains a Wonder Metal still. I refer, of course, to gold. It is not an ideal material for piston rings, is rarely considered seriously as a substitute for 14% manganese steel at railroad crossings, and falls short of perfection even for shaving; but it remains an indubitable Wonder Metal. Its one fatal drawback is the same as that of titanium in its earlier days, referred to at the beginning of this article: it comes dropping slow. Sometimes, in fact, it does not seem to come dropping at all. It is for this reason, perhaps, that the Golden Age remains, stubbornly, a Mythological Concept.

Heat Treatment of Titanium Alloys

*By LEONARD D. JAFFE**

An examination of the large amount of published data leads to a systematic interpretation based on the known properties of the existing microconstituents and their changes during heat treatment.

TITANIUM and its alloys were at first generally regarded as not heat treatable, usefully. More recent work has shown that this was erroneous. Moreover, the effects of composition upon mechanical properties are greatly clarified by considering the simultaneous effects of heat treatment. A very great amount of work has been published or issued for limited distribution, and this article and its sequel will attempt to systematize and rationalize the available data.

At the very outset a broad generalization may be made that the mechanical properties of titanium alloys, like the properties of iron-carbon alloys, depend not so much upon composition as they do upon the phases present and their distribution. In pure titanium the hexagonal close-packed alpha phase is stable from atmospheric temperatures up to 1620° F. (882° C.) whereupon it transforms into a body-centered cubic phase stable at temperatures from 1620° F. to the melting point. Thus the pure metal has certain similarities with iron; in which an "alpha" phase stable at low temperature transforms at 1670° F. (910° C.) to a "gamma" phase, stable at higher temperatures. This comparison is shown in Table I. In many titanium-base alloys, a two-phase structure, alpha plus beta, is stable at room temperature. Beta is never stable at room temperature without alpha.

In other titanium alloys, intermediate phases or intermetallic compounds such as $TiCr_2$, TiFe, TiMn, would occur if time and temperature were sufficient to attain equilibrium, but these phases apparently do not form during normal time for heat treatment. (The exceptions in Ti-C and Ti-H alloys are discussed later.) Accordingly, intermediate phases may ordinarily be neglected, when considering the effects of usual heat treatments; the latter are based upon the equilibrium of alpha and beta. Except for "interstitial elements" (to be described later) and aluminum, alloying elements in titanium stabilize beta at the expense of alpha, giving phase diagrams of the general type of Fig. 1. This diagram has notable similarity to the iron-nickel diagram in the alpha-gamma region.

As suggested in Fig. 1, titanium alloys on

*Long with Watertown Arsenal Laboratory; now with Jet Propulsion Laboratory, California Institute of Technology, Pasadena.

Table I – Crystallography of Pure Metal

	Titanium	Iron
Low-temperature phase		
Name	Alpha	Alpha or ferrite
Crystal structure	Hexagonal close-packed	Body-centered cubic
Lattice constant, a	2.95 A.	2.86 A.
c	4.68	—
Transition temperature	1620° F. (882° C.)	1670° F. (910° C.)
High-temperature phase		
Name	Beta	Gamma or austenite
Crystal structure	Body-centered cubic	Face-centered cubic
Lattice constant	3.29	3.57

cooling undergo a martensite transformation. Beta tends, upon quenching, to transform to a martensitic alpha (called "alpha-prime"). If the Ms temperature is above room temperature, the beta structure after a sufficiently rapid quench will consist of alpha-prime, with or without some retained beta. If the Ms is below room temperature, the quenched structure will then consist of retained beta.

Table II lists the microstructure to be expected in binary allows as it varies with alloy content. The second column lists the weight percent of alloy for complete alpha in slowly cooled samples. The third column lists the range of alloy content wherein Ms is *above* room temperature, and therefore the structure after quenching will be alpha-prime plus some retained beta. The last column defines alloys wherein Ms is *below* room temperature, so the quenched structure will be all beta. The data have been assembled from at least 20 sources.

Table III is probably of more immediate use since it classifies the commercial alloys in groups as to their expected microstructure after very slow cooling and after very rapid quenching. The various commercial titaniums are shown as completely alpha, but a little beta is normally present because of the iron content (about 0.15%). It is not known whether this beta is in equilibrium or would eventually dissolve.

Table II–Structure of Binary Alloys of Titanium at Room Temperature (Weight Percent of Alloying Elements)

Alloying Element	Structure A*	Structures B and C*	Structures B and D*
Al	Up to 25%	—	—
B	" 0.04	—	—
C	" 0.8 *(a)*	—	—
Cb	" 6	6 to 36	36 to 50
Cr	" 1	1 to 6.5	6.5 to 50
Fe	" 0.2	0.2 to 5	5 to 30
H	" 0.2 *(a)*	0.2 to 1.4 *(a)*	—
Mn	" 1	1 to 6.4	6.4 to 40
Mo	" 1	1 to 12	12 to 50
N	" 7	—	—
Ni	" 0.1	0.1 to 8	8 to 10
O	" 15	—	—
Ta	" 15	15 to 45	45 to 50
V	" 4	4 to 15	15 to 50
W	" 1.5	1.5 to 25	25 to 50
Zr	" 50	—	—

*Structure A—Alpha after slow cooling; alpha-beta equilibrium at room temperature.

Structure B—Alpha plus beta after slow cooling; alpha-beta equilibrium at room temperature.

Structure C—Alpha-prime plus beta after quenching; Ms above room temperature.

Structure D—Beta after quenching; Ms below room temperature.

(*a*) Intermediate phases present.

Properties of the Microconstituents – Comparisons of the properties of these three microstructures are somewhat difficult because it is impossible to obtain 100% alpha, beta or alpha-prime with the same composition and the same temperature. In general, however, alpha is relatively soft, ductile, and tough, as shown in Table IV. Beta is somewhat harder and stronger, correspondingly less ductile; and while little is known about its toughness, it is lower than alpha – at least as much as would be expected from the difference in strength.

Data on alpha-prime are scant; even its identification is questionable, as will be explained later. Since it has the same crystal structure as alpha, the difference between them in high-purity titanium can only be a matter of grain shape and size. Alpha-prime produced by quenching from the beta range is somewhat harder and stronger than the figures in Table IV for equiaxed alpha obtained by quenching from the alpha range, and has equal ductility. This is probably due to grain shape rather than grain size. In titanium alloys, alpha-prime is generally richer in alloying elements than equiaxed alpha, since it retains the alloy content of the beta from

which it formed. This probably adds significantly to its hardness. Likewise, alpha-prime in alloys is generally harder than beta of the same composition; for example, Machlin, Weinig and Hendrickson found that in a 6.5% Cr alloy the microhardness of alpha-prime was 446 DPH, of beta 381.

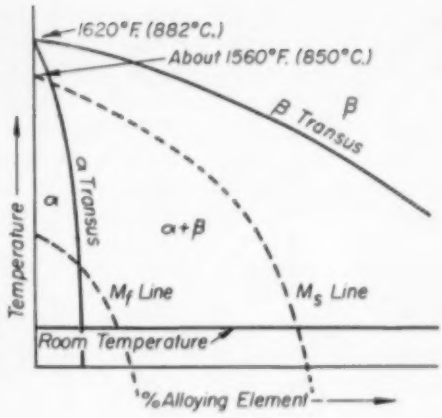


Fig. 1 – Typical Metastable Equilibrium Diagram for Titanium-Base Binary Alloys. Schematic lines Ms and Mf represent martensite start and finish. Ms temperature for pure titanium according to Duwez (Ref. 1). Mf temperatures have not been measured for any of the alloys

Titanium alloys in the alpha-prime condition also have a higher fatigue endurance limit than when annealed to the alpha microstructure. According to Brotzen and Harmon (Ref. 2) this increase is apparently associated with a straightening of the initial portion of the tensile stress-strain curve. In equiaxed alpha structures this portion is curved, indicating that true elastic action is limited, resulting in local deformation and heating under repetitive loading below the yield (measured at 0.2% offset).

Some of the changes in properties of unalloyed alpha titanium observed on heating into the beta range and cooling may simply reflect a decrease in variation of properties with direction. There is evidence that such heating and cooling removes directionality in hardness measurements, even though it sharpens the recrystallization texture. For example, Ogden and his associates (Ref. 4) found that 7.5% Al alloy strip, annealed in the alpha range at 1560° F. (850° C.) had Vickers hardness of 320 on the surface and 240 when measured on a cross section. After holding 30 min. in the beta field and water quenching, there was no difference in hardness with direction; all tests were close to Vickers 295.

When beta is retained by rapid quenching, Holden and co-workers (Ref. 5) find that its strength and toughness are somewhat better if fine grained (0.25 mm.) than if coarser (0.40 mm.). Data on the effect of beta grain size upon properties of alpha-beta mixtures are lacking.

Martensite Transformation – By cooling a quenched alloy that consists of beta plus alpha-prime to various subzero temperatures, retained beta can be transformed to alpha-prime of the same composition. Comparative measurements of the two conditions have so far been limited to hardness; hardness increases with the proportion of alpha-prime retained in the structure.

Quenched alloys with mixed beta and alpha-

Table III – Microstructure of Commercial Titanium Alloys

Designation	Nominal Composition
Alpha after slow cooling	
Iodide titanium	High purity
Ti-75 A	Unalloyed
Ti-100 A	Unalloyed *(a)*
A-55	Unalloyed
A-70	Unalloyed
A-110 AT	Al 5%; Sn 2.5%
RS-55	Unalloyed
RS-70	Unalloyed
MST-111	Unalloyed
Alpha plus beta after slow cooling; Alpha-prime plus beta after quenching	
Ti-140 A	Cr 2%; Fe 2%; Mo 2%
Ti-150 A	Cr 2.8%; Fe 1.5%; O_2 0.2%
Ti-155 A	Al 5.5%; Cr 1.5%; Fe 1.5%; Mo 1.5%
C-130 AM	Al 4%; Mn 4%
RS-110	Cr 4%; Fe 2%
RS-110 BX	Al 1.5%; Mn 3%
RS-130	Al 4%; Mn 4%
RS-140 X	Al 5%; Cr 2.7%; Fe 1.3%
MST-3 Al-5 Cr	Al 3%; Cr 5%
MST-4 Al-4 Mn	Al 4%; Mn 4%
MST-6 Al-4 V	Al 6%; V 4%
Alpha plus beta after slow cooling; Beta after quenching	
Ti-150 B	Cr 4.5%; Fe 4.5%; Mo 4%
C-110 M	Mn 8%
RS-120	Mn 7%
MST-3 Mn Complex	Mn 3%; Cr 1%; Fe 1%; Mo 1%; V 1%
MST-8 Mn	Mn 8%

(a) High in oxygen and nitrogen.

prime have relatively low yield strength because deformation is promoted by further beta to alpha-prime transformation under stress. The martensite reaction seems to be readily inhibited (beta is stabilized) by brief holds at elevated temperatures below the beta transus.

Isothermal Transformation – When a hot alloy in the beta condition – for example, an 11% Mo alloy at 1830° F. – is rapidly quenched into the range where beta plus alpha is stable and held there, precipitation occurs by nucleation and growth with typical age hardening as shown in Fig. 2. Very hard and brittle structures form, the hardness reaching its highest value in an hour or so at 750° F. (400° C.) High hardness may develop before any precipitation is visible under the microscope, and has been ascribed by Frost and his associates (Ref. 7) to a transition precipitate called omega – very difficult to distinguish from beta metallographically or by X-ray diffraction. The formation of omega has a parallel in the sequence of changes during age hardening of other alloys such as aluminum-base.

At high isothermal transformation temperatures, visible alpha forms first at grain boundaries, later as plates within the beta grains. At lower transformation temperatures, alpha appears as a fine precipitate within the grains, becoming finer as the temperature is lowered. To what extent the brittleness observed in alloys transformed for short times or at low temperatures is associated with grain-boundary or finely dispersed alpha, and to what extent it is associated with omega, has not yet been determined.

Whatever these factors are in producing hardness and brittleness, they disappear rather rapidly at higher transformation temperatures. Moderate strength with good toughness and ductility is then obtained, the structures consising of alpha particles in a beta matrix. The observed gradual rise in tensile strength in samples transformed for longer and longer times at fairly high temperatures seems to be due not to an increase in hardness, but to an increase in ductility, so that the material no longer breaks before necking in the tensile test. An instance in point is as follows (data from Ref. 6 for 11% Mo alloy transformed at 1290° F.):

Time	Strength	R. A.
5 min.	101,000 psi.	13%
15	113,000	9
30	122,000	42
60	125,000	40

At lower temperatures, high hardness and brittleness persist much longer. As to hardness, see the curves for 570 and 750° F. in Fig. 2. As to brittleness, take the following data for the 11% Mo alloy transformed at 840° F. (450° C.):

Time	Strength	R. A.	Impact
5 min.	136,000 psi.	0%	14 ft-lb.
15	150,000	3	6
30	197,000	5	12
60	–	–	3

Beta decomposition also should slow at temperatures just under the beta transus. As in other age hardening systems, the height of the peak shown in Fig. 2 is less at high transformation temperatures. If the time of isothermal transformation is sufficiently long, it appears that the effect of the ratio between existing phases will dominate. Thus, alpha is softer than beta and at lower temperatures more alpha is present at equilibrium; this lowers the strength but raises the ductility.

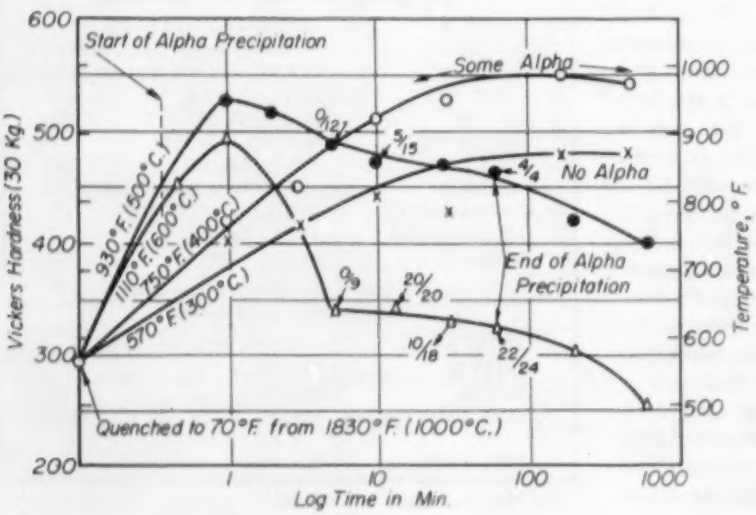


Fig. 2 – Hardness-Time Curves of 11% Mo Alloy During Isothermal Transformation. Typical age hardening is indicated. Fractional figures represent % reduction of area (numerator) and V-notch Charpy (denominator). From DeLazaro and co-workers, Ref. 6.

Table IV – Properties of High-Purity Titanium* (100% Alpha)

Alpha Grain Size and Shape	Quenched From	Tensile Properties (a)				Impact Energy (b)			
		Yield	U timate	Elong.	R.A.	77° F.	−40° F.	−110° F.	−325° F.
0.01 mm. equiaxed	1 hr. 1110° F.	25,000	41,000	58%	85%	73	70	80	88
0.06 mm. equiaxed	1 hr. 1475° F.	18,000	36,000	82	89	150			
0.10 mm. equiaxed	2 hr. 1610° F.	18,000	36,000	76	89	156	164	154	160
0.20 mm. equiaxed	100 hr. 1610° F.	18,000	38,000	76	91	154			
0.25 mm. jagged-edged	1 hr. 1830° F.	33,000	42,000	64	87	132	129	125	119
0.25 mm. smooth-edged	Same, furnace-cooled	24,000	38,000	66	85	92	120	120	104

*Iodide-purity titanium arc melted, forged at 1600° F. to ¾ in., descaled, vacuum-annealed 6.5 hr. at 1650° F., cold-swaged to ½ in., annealed in air 1 hr. at 1560° F., descaled, cold-swaged to ¼ in., treated in argon as noted. Single-specimen tests by Jaffee, Ogden and Holden (Ref. 3).

(a) Yield strength was measured at 0.2% offset; elongation is % in 0.5 in.

(b) Subsize Izod specimens, in-lb.

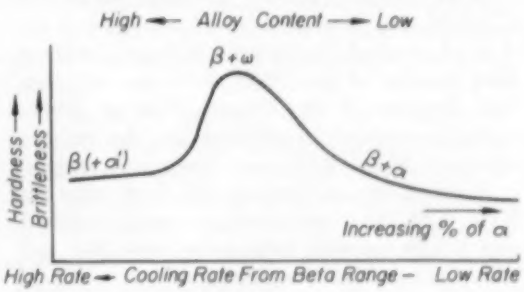
Beta not transformed isothermally may transform to alpha-prime on subsequent quenching, but any precipitation of omega impedes the subsequent formation of alpha-prime. Furthermore, as alpha forms isothermally, the remaining beta becomes progressively enriched in alloying elements. This enrichment is greater in alloys transformed at low temperatures, where more alpha can form, and is often sufficient to reduce the Ms of the remaining beta to below room temperature. Thus isothermal transformation can actually increase the retention of beta phase in the microstructure. The composition of the enriched beta and the rate of quenching to room temperature may be such that omega forms during the quench, with corresponding increase in hardness and brittleness.

The kinetics of the $\beta \rightarrow \alpha$ transformation by nucleation and growth have not been investigated below the Ms temperature, as far as the author is aware. This matter would seem to be important, as Ms temperatures may be as high as 1560° F. (850° C.). In pure titanium, kinetics of the transformation by nucleation and growth do not seem to have been investigated at all.

Continuous Cooling – The effect of variations in cooling rate from the beta range may be generalized in terms of Fig. 3. At sufficiently high cooling rates (toward the left of the diagram) the structure as-quenched consists of retained beta, of moderate hardness. If the Ms is above room temperature, alpha-prime will also form, contributing some additional hardness. At slower cooling rates (at the middle of the diagram) omega will precipitate from the beta, giving a hard and brittle structure, and since the Ms is apparently depressed by omega formation, less alpha-prime will be present. At still slower cooling rates (at the right of the diagram) the beta plus omega will transform to beta plus alpha, and as alpha precipitates out, hardness falls, ductility and toughness rise; any alpha-prime that forms will temper significantly before reaching room temperature, again giving a structure of alpha plus beta.

This generalized diagram may also be used to indicate the effect of alloys, and this will be done in some detail in a second article to follow next month. Suffice it to say here that structure of a high alloy – say 12% Mn – would be all-beta whether quenched or slowly cooled from a high temperature, and commercially pure titanium would be principally alpha.

Fig. 3 – Curve Showing General Relationship Between Cooling Rate, Resulting Microstructure, Hardness and Brittleness of Titanium Alloys. (After Jaffe, Ref. 8)



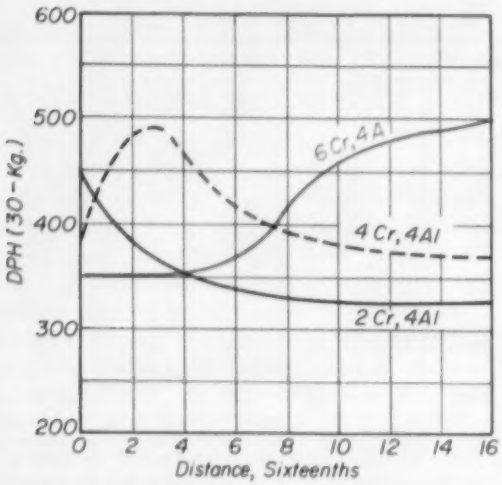


Fig. 4—Jominy Tests on Low, Medium and High Alloyed Metal, After Kessler and Hansen (Ref. 9)

Jominy Hardenability – For any one alloy, only a small portion of the range of cooling rates indicated in Fig. 3 will be included in an end-quench hardenability test (Jominy test). The types of such curves that have been found in Ti-Al-Cr alloys are illustrated in Fig. 4. The curve for 2 Cr, 4 Al is typical of the leaner alloys, including such commercial alloys as Ti-150 A and C-130 AM. Here hardness is highest at the water-quenched end, and falls as the cooling rate is decreased toward the air-cooled end of the hardenability bar. (This composition falls in the right portion of the alloy field and produces $\beta + \alpha$.) Corresponding changes in tensile and impact properties of a similar alloy (4 Mn, 4 Al) cooled from 1830° F. (1000° C.) were measured by Phillips (Ref. 10):

	Quenching Medium			
Property	Brine	Oil	Air	Furnace
Yield	173,000	144,000	122,000	117,000
Ultimate	173,000	162,000	140,000	134,000
Elongation	0	5%	14%	14%
Brinell	404	368	307	305
Charpy	6 ft-lb.	9 ft-lb.	22 ft-lb.	19 ft-lb.

In intermediate alloys, including commercial C-110 M, and illustrated by the curve for 4 Cr, 4 Al which straddles the peak of Fig. 3, hardness rises because of formation of omega and then falls because of its decomposition at slower cooling rates to alpha and beta, and also because whatever alpha-prime may form will temper.

In rich alloys, as shown in the third curve for 6 Cr, 4 Al, the structure at the water-quenched end is soft retained beta; away from this end where omega forms the hardness rises.

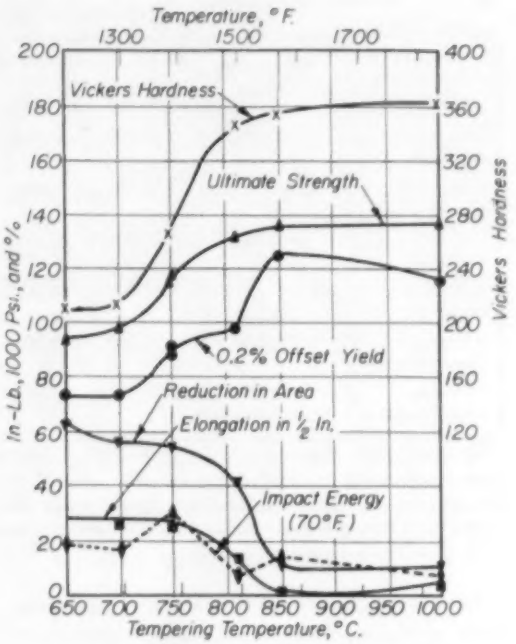


Fig. 5 – Effect of Reheating 1 Hr. and Water Quenching on Properties of a 3.4% Mn Alloy (High-Purity Titanium). After Holden, Ogden and Jaffee, Ref. 5

Increased content of beta-stabilizing alloying elements, then, may be considered as increasing the hardenability of titanium-base alloys. This usage of the term "hardenability" is consistent with that for steels, where hardenability means "ability to be quenched from the austenite range to room temperature without transformation by nonmartensitic reactions". Substituting "beta" for "austenite", the same definition holds.

Figure 3 suggests that titanium with little or no alloy content will consist of alpha phase formed by the reaction $\beta \rightarrow \beta + \omega \rightarrow \beta + \alpha \rightarrow \alpha$ rather than $\beta \rightarrow \alpha'$ on both air cooling and water quenching. If the start of martensite formation is at a high enough temperature, alpha-prime undoubtedly forms, but there is reason to believe that the first mentioned four-step reaction, involving nucleation and growth, actually does take place very rapidly in unalloyed titanium. Duwez (Ref. 1) found that the temperature of the thermal arrest associated with $\beta \rightarrow \alpha$ transformation can be lowered 30° C. by increasing the cooling rate. Some of the so-called martensite observed in unalloyed titanium may therefore have formed by nucleation and growth; this introduces some doubt as to the properties of the alpha-prime phase reported in the literature.

Tempering – When alpha-prime is heated, it will change to the alpha phase. Since alpha-prime generally contains more than an equilibrium amount of alloying elements, these will diffuse into nearby beta. Relatively little change in microstructure occurs until tempering reaches 900° F. (500° C.) or so. Any mixture of alpha-prime and beta then becomes coarser and spheroidized; in the absence of beta the alpha changes from acicular to serrated.

Phillips (Ref. 10) has studied the tempering of a 4 Mn, 4 Al alloy that was brine quenched from 1835° F. (1000° C.). Changes are primarily due to the tempering behavior of alpha-prime, on which are superimposed the effects of a little beta-plus-omega. Hardness was decreased on tempering 1 hr. at various temperatures, and ductility rose:

Temperature	Brinell Hardness	Tensile Elongation
As-quenched	404	0%
700° F. (370° C.)	385	< 1
1000° F. (540° C.)	365	1.6
1275° F. (690° C.)	332	4
1450° F. (790° C.)	324	7
1610° F. (875° C.)	304	9

At long tempering times it appears that the prime variable is the relative amounts of alpha and beta; more alpha will exist at equilibrium at low temperatures, so the strength will eventually fall to lower levels at low heat treating temperatures than at high. This is particularly noticeable in material previously worked in the alpha-beta temperature range, as in Fig. 5. Here ductility is high after low tempering temperatures at the expense of hardness.

Likewise, alpha phase has better toughness than beta phase. For example, Holden, Ogden and Jaffee (Ref. 5) find that a high-purity alloy with less than 5% beta (0.55% Mn) gives 70 to 80 in-lb. impact energy at all temperatures between −325 and +300° F. (−200 and +150° C.), whereas an alloy with 25% beta in its microstructure (4.4% Mn) showed 14 in-lb. at −325° F., consistently increasing with testing temperature but getting no higher than 60 in-lb. at +300° F., and a 100% beta material (12% Mn) was at least 15 in-lb. lower at all temperatures.

Occasionally very marked hardening may occur in material tempered and then quenched, if the tempering temperature – 1300 to 1650° F. (700 to 900° C.) – the time, and the cooling rate are such that enriched beta forms of a composition from which omega precipitates during the quench. The hardness after tempering and quenching then may go through a peak as the tempering time increases, giving a hardness-vs-time curve suggestive of age hardening, but actually analogous to secondary hardening in high speed steel.

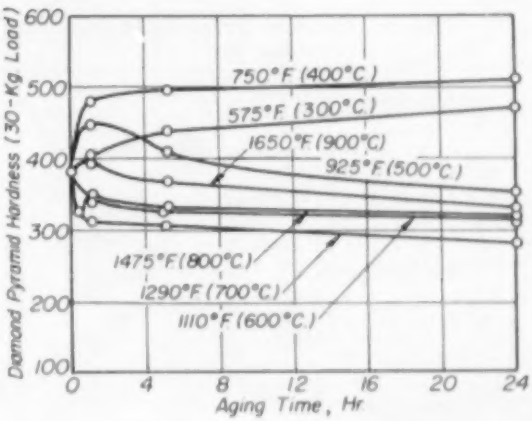


Fig. 6 – Hardness Changes During Tempering of Commercial-Purity 2 Al, 4 Cr Alloy, Previously Water Quenched From the Beta Phase. (Kessler and Hansen, Ref. 9)

When a high alloy in which beta has been retained by quenching is reheated, this beta transforms to beta plus omega and then into a mixture of beta and alpha. Typical age hardening curves result, the hardness peak being higher at low aging temperatures but attained more rapidly at high temperatures. With such alloys as 15% V and 4 Cr, 2 Al, one hour at 750° F. (400° C.) gives about as high hardness as can be attained with any treatment of reasonable length. Figure 6 shows hardness curves for the 2 Al, 4 Cr alloy, and Table V shows properties; at peak hardness such metal is very brittle; on "over-aging" reasonable ductility returns.

The tempering curve starts from the condition prior to tempering. If the material is already at peak hardness (beta plus omega) before tempering, it can only soften during the temper; if it is already overaged (beta plus alpha) before tempering, even a temper at 1250° F. (675° C.) can only soften it a little more. In some alloys a second hardness peak is found on long aging, possibly due to precipitation of an intermediate phase (intermetallic compound) by a eutectoid reaction.

It might be expected that the behavior of retained beta on reheating and the resulting properties would be about the same as that of beta quenched directly to the aging temperature and held for the same time, but the presence of alpha-prime might nucleate and accelerate transformation of retained beta.

Table V – Effects of Tempering (Aging) Retained Beta

Temp.	Time	Tensile Strength	Elong. (1 In.)	Vickers Hardness
15% Vanadium Alloy (a)				
Room		108,000	14%	330
250° F.	26 hr.	134,000	2	425
400	1	155,000	1	435
600	1	112,000	1	515
4% Chromium, 2% Aluminum Alloy (b)				
Room		165,500	3%	387
750° F.	5 hr.	Too brittle for good test		
930	1	156,400	1.5%	421
1110	1	137,600	1.0	340
1290	1	135,000	11.0	297

(a) Three-eighths-inch bars forged from 0.5-lb ingots. Solution treated 5 hr. at 1375° F. (745° C.) and quenched in iced brine (Ref. 11).

(b) Alloy of commercial purity studied by Kessler and Hansen (Ref. 9). Prior treatment: 30 min. at 1650° F. (900° C.) in beta field, water quenched.

Differences in behavior on reheating and on direct quench have been reported but the data have not been systematized. In most cases the hardness is higher and toughness lower after quench and reheat than after isothermal transformation for the same time and temperature.

Solution Treatments – It has been stated by Parris and co-workers in Reference 12 that better ductility is attained with a given (high) strength by solution treating in the upper portion of the alpha-beta range, quenching, and then overaging, than by quenching from the beta range and overaging. Suggested reasons include a theory that grain growth of beta is prevented, and another that alpha occurs as spheroids rather than as plates and grain-boundary precipitate. Rolling in the alpha-beta range prior to solution treatment is likewise reported to give superior ductility to rolling in the beta range.

Referring to Fig. 3, solution treatments below the beta transus may be represented as splitting the alloy into two constituents – soft alpha and beta enriched in alloys. Thus, the beta is shifted to the left on the curve and its hardenability is increased. This might, for instance, result in a peak developing in a Jominy curve on quenching from a low temperature when there is no peak on quenching from the beta range, or in shifting the peak to lower cooling rates. Also, the hardness may then peak on tempering, when it did not do so after the quench from high temperature. On this, a general softening due to alpha constituent would be superimposed.

References

1. "Effect of Rate of Cooling on the Alpha-Beta Transformation in Titanium and Titanium-Molybdenum Alloys," by P. Duwez, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 191, 1951, p. 765 to 771.

2. "Fatigue and Ageing Properties of Titanium-Vanadium Alloys", by F. R. Brotzen and E. L. Harmon, Case Institute of Technology, not yet published.

3. "Mechanical Properties of Alpha Titanium as Affected by Structure and Composition", by R. I. Jaffee, F. C. Holden and H. R. Ogden, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 200, 1954, p. 1282 to 1290.

4. "Mechanical Properties of High Purity Titanium-Aluminum Alloys", by H. R. Ogden, D. S. Maykuth, W. L. Finlay and R. I. Jaffee, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 197, 1953, p. 267 to 272.

5. "Heat Treatment, Structure and Mechanical Properties of Titanium-Manganese Alloys", by F. C. Holden, H. R. Ogden and R. I. Jaffee, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 200, 1954, p. 169 to 184.

6. "Time-Temperature-Transformation Characteristics of Titanium-Molybdenum Alloys", by D. J. DeLazaro, M. Hansen, R. E. Riley, and W. Rostoker, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 194, 1952, p. 265 to 269; and "Correlation Between Heat Treatment, Microstructure and Mechanical Properties of Titanium-Molybdenum Alloys", by D. J. DeLazaro and W. Rostoker, *Transactions*, American Society for Metals, Vol. 46, 1954, p. 292 to 311.

7. "Isothermal Transformation of Titanium-Manganese Alloys", by P. D. Frost, W. M. Parris, L. L. Hirsch, J. R. Doig and C. M. Schwartz, *Transactions*, American Society for Metals, Vol. 46, 1954, p. 1056.

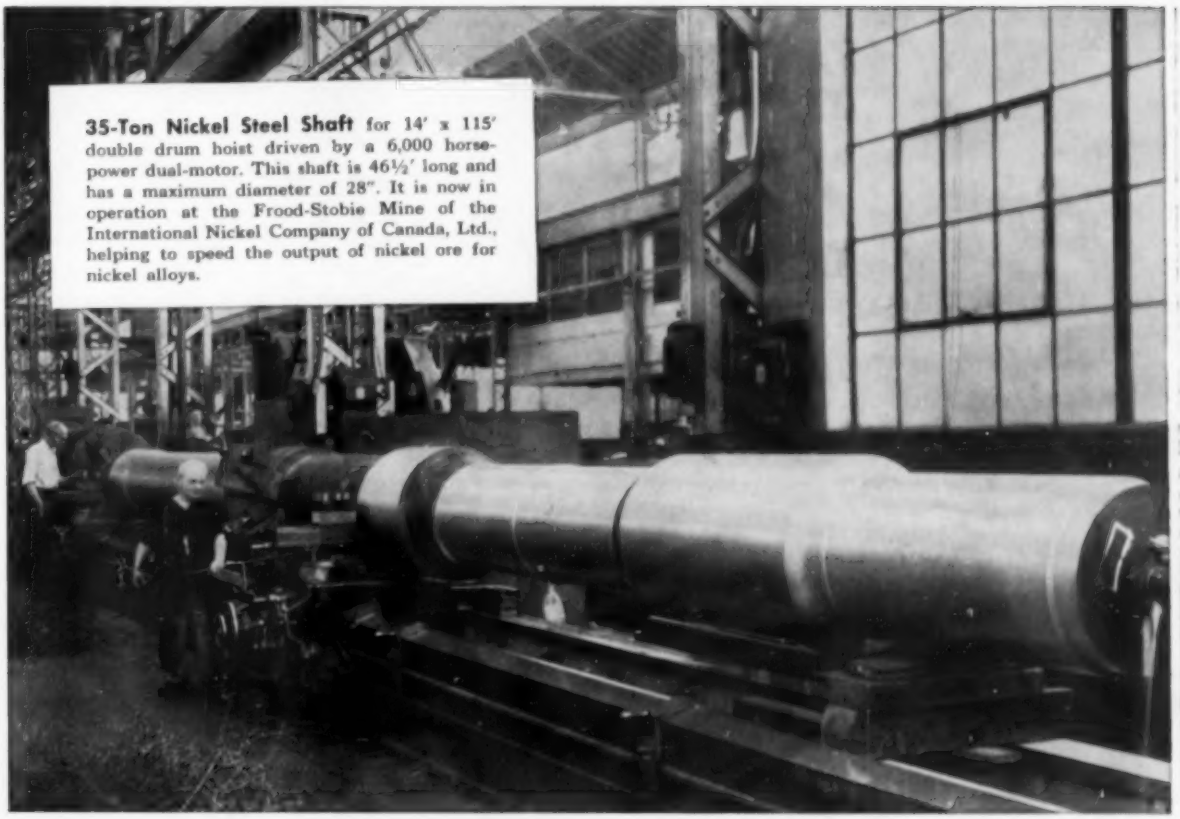
8. "Heat Treatment of Titanium Generalized in Terms of Beta Prime", by L. D. Jaffe, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 200, 1954, p. 210.

9. "Transformation Kinetics and Mechanical Properties of Titanium-Aluminum-Chromium Alloys", by H. D. Kessler and M. Hansen, *Transactions*, American Society for Metals, Vol. 46, 1954, p. 609 to 639.

10. "Phase Transformations and Heat Treatability of Titanium-Base Alloys", by C. W. Phillips, University of Michigan, not yet published.

11. "The Titanium-Vanadium System", by H. K. Adenstedt, J. R. Pequinot and J. M. Raymer, *Transactions*, American Society for Metals, Vol. 44, 1952, p. 990 to 1003.

12. "Heat Treatment of High-Strength Titanium-Base Alloys", by W. M. Parris, P. D. Frost and J. H. Jackson, *Transactions*, American Society for Metals, Vol. 46, 1954, p. 568 to 586.



35-Ton Nickel Steel Shaft for 14' x 115' double drum hoist driven by a 6,000 horsepower dual-motor. This shaft is 46½' long and has a maximum diameter of 28". It is now in operation at the Frood-Stobie Mine of the International Nickel Company of Canada, Ltd., helping to speed the output of nickel ore for nickel alloys.

How nickel strengthened the shaft for Canada's highest powered mine hoist

IN LARGE FORGINGS such as this giant shaft, high tensile and elastic properties do not come easily.

Liquid quenching of heavy forgings is usually impractical. Even when the shape is such that this treatment may be safely applied, the section sizes involved often restrict cooling to rates which render the quench ineffective.

Increased strength, hardness, toughness and other mechanical properties in a large forging depend to a great extent upon selection of alloy content.

Accordingly, to attain maximum strength and toughness in the shaft of Canada's highest powered mine hoist, at our own Frood-Stobie mine, we specified a shaft forged of 3½% nickel steel . . .

Because nickel, either alone or in combination with other alloying elements, provides a number of advantages.

For one thing, it has a strengthening effect on ferrite . . . independent of carbon content or heat treatment of the steel.

For another, it lowers the rate and temperature of the upper transformation, thus inducing better response to the necessarily milder heat treatments used. And it reduces grain growth.

Whenever you face a metal problem, let us help you make a selection that will meet your particular fabricating and service requirements. Send us details of your applications, for our suggestions.

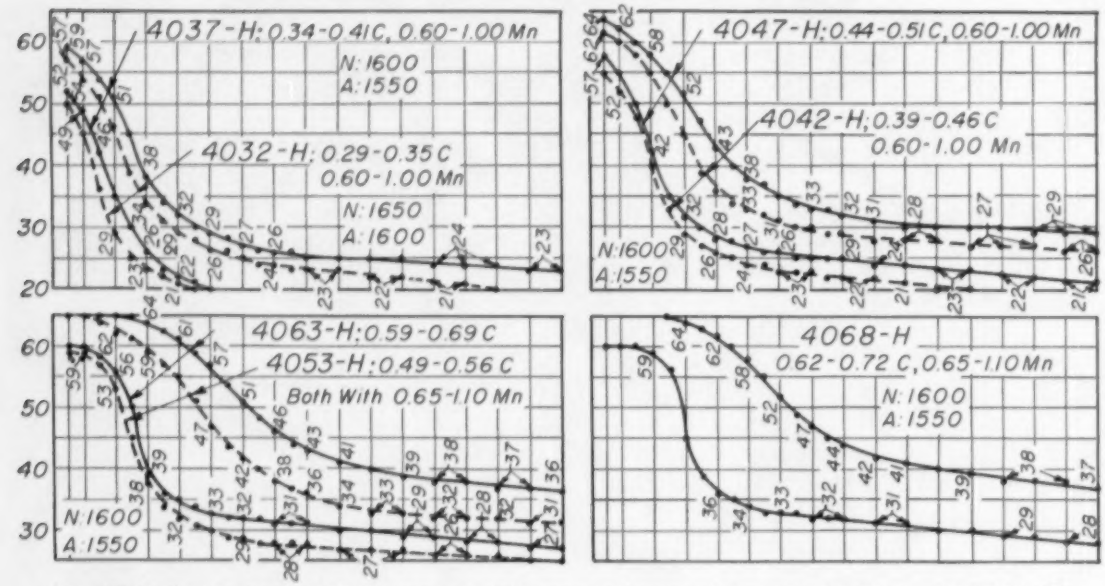
INCO
TRADE MARK

Double Drum Hoist for the Frood-Stobie Mine, during course of shop erection by the builder, The John Bertram & Sons Co., Ltd., Dundas, Ontario. Spiders that support the steel shell of the hoisting drum were cast in an iron containing 1½% nickel . . . to assure adequate strength in the 74,600-pound drum-spider assembly. This hoist, operated by push button control from a station far underground, can lift skips containing 15 tons of nickel-copper ore, at an average rate of 14,000 tons daily.

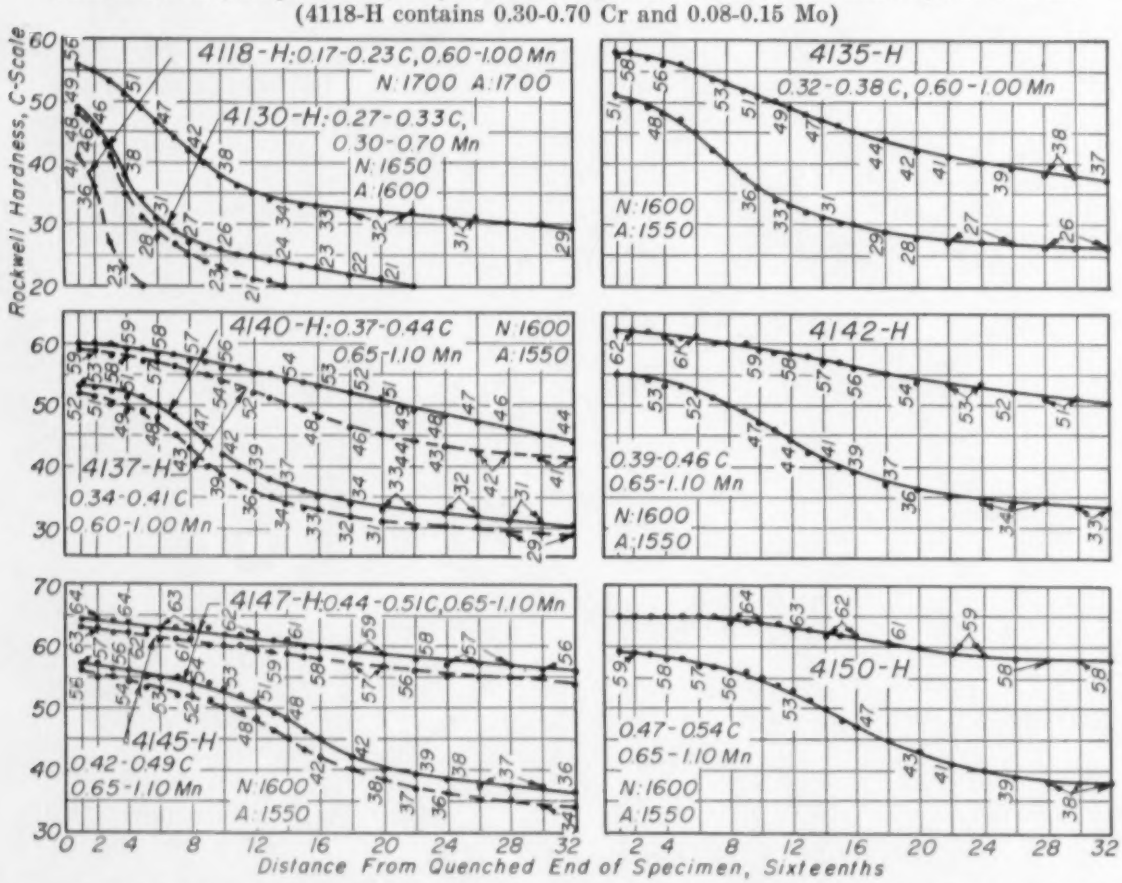
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Standard H-Steels, 4032-H to 4150-H

40xx-H Series may contain 0.20-0.35 Si and 0.20-0.30 Mo



41xx-H Series (except 4118-H) may contain manganese as shown, 0.75-1.20 Cr, 0.15-0.25 Mo
(4118-H contains 0.30-0.70 Cr and 0.08-0.15 Mo)



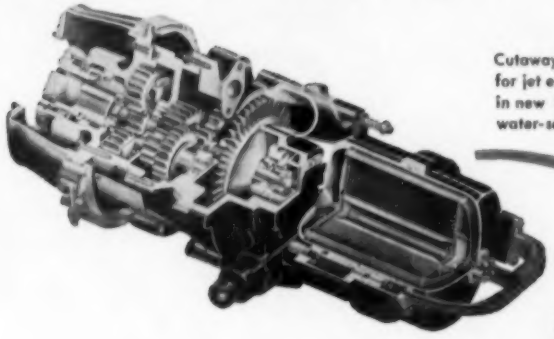
N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

Rapid deep case

for jet engine starter clutch

with new AEROCARB® carburizing compounds



Cutaway of a General Electric gas turbine starter for jet engines shows clutch components they carburize in new high-speed, high-temperature, water-soluble AEROCARB Carburizing Compounds.

Sleek new Martin B-57 jet light bomber has starters housed in streamlined pods seen at each engine air intake opening.

Clutch mechanisms for gas turbine starters must deliver tremendous power to bring jet engines to starting speed. To get the toughness and strength they need, General Electric Company's Aircraft Accessory Turbine Dept. at Lynn, Massachusetts, carburizes these parts in Cyanamid's new, high-speed, high-temperature AEROCARB S and (as the bath replenisher) AEROCARB R Carburizing Compounds.

Chief feature of these new AEROCARB compounds is deep and rapid penetration with minimum distortion. Many of the parts require 0.060" case depth, which G-E achieves at 1650-1750° F in just 8-9 hours with AEROCARB water-soluble salts. They use the same salt bath for their short time, shallow case work. Drag-out from this bath is low; wash-off is fast, easy, and complete with warm water.

These remarkable new AEROCARB carburizing compounds can solve your case hardening problems — give you high quality results in less time and at lower cost. The attached coupon is for your convenience.

Cyanamid's heat treating compounds include:		*Other products for metal processing include:*	
AEROCASE®	Carburizing Compounds	**AEROMET®**	Metallurgical Additive
AEROCARB®	Case Hardening Compounds	Metallic Stearates	
AEROHEAT®	Heat Treating Compounds	Surface Active Agents	
		Acids and other Heavy Chemicals	

®Trade-mark

MP2-55

AMERICAN Cyanamid COMPANY

METAL CHEMICALS SECTION

30 Rockefeller Plaza, New York 20, N. Y.

☐ Send technical data sheet on AEROCARB S

☐ Have technical representative call

Name_____ Position_____

Company_____

Address_____

City_____ State_____

In Canada: North American Cyanamid Limited, Toronto and Montreal

EASIER ON YOUR EYES!

Exclusive with the

Bausch & Lomb

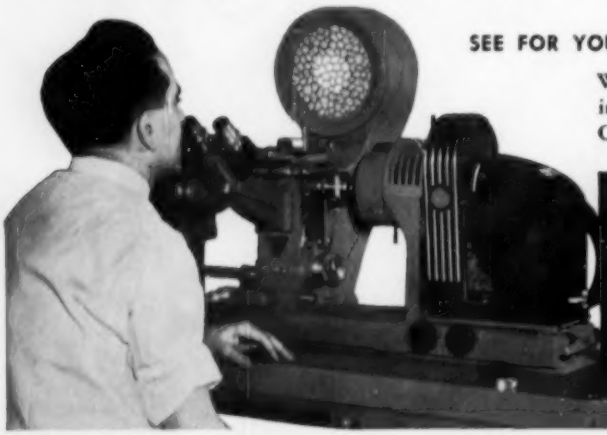
BALPHOT

Metallograph

Only Bausch & Lomb gives you the Magna-Viewer projector screen—high-contrast images for easier study at selected magnifications.

- Comfortably located in the operator's natural line of vision; convenient for group viewing, for consultation.
- Ends visual fatigue in extended examinations, structure study, grain size determinations and dirt counts.
- Uniform image brightness, center to edge; easy to see in full room illumination.

A flick of a switch instantly shifts image to microscope or 5x7 camera (25× to 2000× magnification). You remain comfortably seated, fatigue-free. And . . . the Magna-Viewer is just one of the many B&L advantages that make it easier for you to do your best work.



SEE FOR YOURSELF IN AN ACTUAL DEMONSTRATION!

Write for obligation-free demonstration and for informative Catalog E-232. Bausch & Lomb Optical Co., 63838 St. Paul St., Rochester 2, N. Y.

BAUSCH & LOMB

SINCE B&L 1853

AMERICA'S ONLY COMPLETE OPTICAL SOURCE . . . FROM GLASS TO FINISHED PRODUCT

"Plancor 422" –A Wartime Steel Plant

*By M. E. GOETZ**

Troubles surmounted in design, construction and emergency operation of an integrated plant for making gun steel or aircraft quality steel from molten pig and own scrap, by duplexing openhearth and electric furnaces and rolling large ingots into forging blooms.

ALL AMERICANS will remember the series of events which led to Pearl Harbor and our entry into World War II. American industry was already expanding to take care of lend-lease and our own mobilization. Early in 1941 the Defense Plant Corp. determined that the steel capacity of this country should be increased by 10,000,000 tons and scanned the various steel companies to ascertain how this could be accomplished.

America was particularly short in electric furnaces and forge and press capacity. Our electric furnace capacity, which was 2% of total steelmaking capacity in 1929, had grown to only 2.2% of the total by the beginning of 1940. Compare this to the German figure of 5.9%, which proportionate figure America would have to match at the very least. Since the steel market was moving toward the Middle West, Chicago was the logical place for additional electric furnace capacity, and since Republic Steel Corp. had long been a manufacturer of alloy steels in electric furnaces in its Canton and Massillon (Ohio) plants, it became a logical choice for this phase of the necessary wartime expansion. We already had at South Chicago alongside the navigable Calumet River, eight openhearths, old rolling mills and a very modern wire and wire products mill. Also some vacant land alongside. The vacant land and river are shown in Fig. 1, with the old plant in the smoke and haze at left background.

At the request of the Defense Plant Corp. a tentative layout for a new plant in Chicago was completed on Aug. 18, 1941, to show what might be done in this district. These plans were hashed and rehashed many times. Later in the year we received instructions from the general office of Republic Steel Corp. to hire draftsmen immediately. We had to find a place in South Chicago where they could be put to work, and they were housed in the top floor of our old (and "old" is meant) wire mill at Grand Crossing, five miles away. Our entire engineering department was moved into these quarters Dec. 1, 1941, a week before Pearl Harbor. A letter of intent came from

*District Manager, Republic Steel Corp., Cleveland. This story was told to the Penn State Chapter of the American Society for Metals when the author was awarded the 1954 David Ford McFarland Award for achievement in metallurgy, presented annually to a graduate of the College of Mineral Industries of the Pennsylvania State University.

Fig. 1 – Site as It Appeared in March 1942, Eleven Months Before First 100-Ton Heat of Electric Steel Was Poured. Calumet River at right; old plant shows in left background

the Defense Plant Corp. on Jan. 6, 1942, and on Jan. 12 ground was broken.

Philosophy of the Design

Michael Yatsevitch, a big-gun expert at Watertown Arsenal, had predicted long before the start of World War II that the United States would have no other way to make guns than from rolled blooms or billets. Following out this idea in 1932 at Republic's Canton Plant six gun blooms were made and rolled. To the best of our knowledge these were all that had been rolled in the U.S. up to the 1942 ground breaking of an integrated plant for doing it on a large scale! Germany was producing and rolling gun blooms regularly for manufacture of cannon, and the English were already rolling the smaller gun tubes for field artillery.

After Pearl Harbor it was agreed that everything possible must be done to expedite the production of tubes or barrels for the larger caliber guns and howitzers. Production had been confined to government arsenals and to a few industrial plants making ordnance. All of the tubes or barrels for the large-caliber guns were being forged (usually press forged) direct from ingots, which was not only time-consuming but further reduced the available facilities. In this situation Republic Steel Corp. agreed to roll large blooms which would meet the exacting gun specifications upon being subsequently forged, machined and heat treated. This was a large undertaking and it meant rolling mills capable of producing big rounds and round-cornered squares to the size tolerances of commercial bars, together with oversize soaking pits and all the slow cooling equipment necessary to prevent flaky steel, as well as a metallurgical laboratory (probably staffed with women) capable of handling 100 tons – yes, *tons* – of samples daily. Since the electric furnace lends itself better to the accurate controls and the quality needed for gun blooms, as well as for the production of aircraft quality steels, the refining was to be done in electric furnaces. Since no scrap could be guaranteed, the plant had to be an integrated one and use molten pig iron made on the premises. Only high-phosphorus ores were available, which presented additional metallurgical problems. Menominee ore from Escanaba, Mich., could be shipped by rail so this wartime plant could operate in case the locks at Sault Ste. Marie were destroyed. The blast furnace should produce 1250 net tons of iron a day, and a battery of 75 coke ovens was necessary. A byproduct plant was added for good measure!

To reduce electric power requirements, a battery of tilting openhearths took the pig iron and delivered low-phosphorus metal of known analysis to the electrics – a method proven at Republic's Canton plant where molten openhearth metal was used as an electric furnace charge. The scrap shortage dictated a high iron charge in the openhearths, and inasmuch as high iron charges require slag flushing (particularly with high-phosphorus, high-sulphur iron) tilting openhearths seemed particularly desirable.

The hot steel tapped from the openhearth would be low in phosphorus, sulphur, and silicon, somewhat higher (about 10 points) in carbon than the product to be made in the electric furnace, and sufficiently hot so it would not freeze on the bottom. The molten steel could be charged into the electric furnace through the charging door, using a brick-lined spout just as in charging hot metal into openhearths.

All this required land – more land than we had, in fact, no matter how closely we figured and squeezed the equipment. It would take too much time to tell how we had to move a railroad, fill in an existing turning basin for ore boats, or find space for a "high line" serving the blast furnace. The latter was secured from our neighbors, Interlake Iron Corp., plus the Pennsylvania Railroad and the owners of three small properties. There were of course some price disagreements. The matter was very urgent, and if you have had any experience with lawyers trying to work out complicated transactions, you can appreciate the days that were spent working out the details. The chief engineer of the Chicago Division of the

Fig. 2 – Aerial View of Completed Plancor 422 (Blast Furnace and Coke Ovens in Foreground, Melting Shop and Rolling Mills With Bright Roof Tops) Alongside Old South Chicago Plant of Republic Steel

Pennsylvania Railroad (incidentally, a Penn State graduate), remarked to me that if they would let us alone for five minutes we could complete the whole transaction. Fortunately they didn't, so the property transfer was finally worked out legally to where it should stand all tests.

One of the first things that had to be fixed long before commencing construction was a sufficient supply of power. Numerous trips were made to the Commonwealth Edison Co., who agreed, without publicity, that they would have sufficient power for us. The final power contract called for 85,000 kw., which to the best of our knowledge is the largest one ever signed in Chicago and the amount is exceeded only by the combined load of the elevated and surface lines of the Chicago Transit System.

Since Republic Steel Corp. did not have the engineering or construction forces for erecting such a plant, on Jan. 19, 1942 James Stewart and Co. was selected to do the engineering and be the general contractor. This large contracting firm had never built a steel plant. The first move was to erect a large two-story building across the tracks from the site. This was soon given the title of "The Hotel" and numerous requests were received for rooms with southern exposure, and so on. Later on, when workmen were scarce, Jamaican laborers actually turned this office building into a hotel!

One day, while on a hook-up with the management in Cleveland and with the manager for James Stewart, the word "Mister" was used several times. Before the end of that conversation the instructions were that if the project was to go along the "Mister" would have to be eliminated.

Plant Layout

As shown by the aerial view, Fig. 2, taken after the War, the blast furnace, by pure good fortune, was located on a limestone ledge only 14 ft. below the surface. It sloped off rapidly in both directions, so the blast furnace is on the only absolutely solid bed in the plant area! In order to get the four tilting furnaces and the six electrics into the melt shop, two of the furnaces landed on fill in what had been the turning basin. Word came that the number of electric furnaces should be nine instead of six. Could they be worked in? One of our engineers came up with the idea that by making the furnaces right and left-handed, all nine furnaces could be worked into the old layout by extending it one additional bay. Could the number of furnaces be increased to eleven – or could two electric furnaces be put into our old openhearth shop? Neither was feasible, so that the plant remained a nine electric furnace shop. The electric furnace capacity was established at 62,500 tons of ingots. It was planned so that six of the nine furnaces would be charged with hot metal from the tilting openhearths and the remaining three furnaces, charged cold, would use returned mill scrap.

The blooming and bar bills could not be laid out parallel to the Pennsylvania Railroad nor to the Calumet River, but had to be put in diagonally. The soaking pits had to be put in diagonally to the mill building.

One day, in looking at the general elevation drawing for the 44-in. reversing blooming mill, Claassen, our chief engineer, said he thought the craneway was too low to lift out the blooming mill screws, should it be necessary to change them. Sure enough, a recheck of detailed drawings showed that the building height was ½ in. short, and the roof had to be raised. There is nothing in the world that will take the place of experience!

A hot scarfing unit was provided along with a very heavy electric shear. Since many tests would be required for aircraft and gun quality steels, a retractable chute could be run underneath the shears, and the test piece would slide down onto a conveyer, taking it up into a small metallurgical

Fig. 3 – View of Stock House (Behind Truck), Electric Furnace Building (Behind Tall Crane) and Stripper Building (Sheathed Building at Right) on April 3, 1943, When First Electric Furnace Was Started

laboratory with a steam hammer and annealing furnaces to provide for proper metallurgical handling of the hot tests.

The bar mill, as selected, consisted of a 36-in., two-high reversing mill and three stands of 32-in. mill cross country. Slow cooling facilities were included both for blooms and finished products. Hacksaws and rotary saws were installed, as well as facilities for mechanical grinding, pickling, rotary and gag straighteners, four large car-type furnaces for slow cooling of blooms, and ten in-and-out type of annealing furnaces. Under this one roof there are 23 acres, comprising the blooming mill and the bar mill.

Construction

One could go on and on about the difficulties encountered daily. For example, cranes. While Morgan Engineering Co. and Alliance Machine Co. could and did build the heavy cranes, we needed about 23 lighter ones, and everybody else was busy. Finally we located an outfit in Omaha which had never built a crane but figured it could if someone else would make the bridge trusses. Bethlehem did that, and an excellent job was delivered – these 23 cranes have continued to work with practically no delays.

Even in wartime we ran into labor troubles. Some laborers and a locomotive crane unloaded a couple of cars of pipe one night and the next day the pipefitters, claiming that it was their work, struck for a week. It was ruled finally that it was to be the pipefitters' work, whereupon the laborers went on strike. Six weeks passed before the matter could be straightened out and everyone brought back to work again.

"Priorities" were a constant headache, as everyone remembers. Priorities had to be obtained for the necessary steel, and "Plancor 422" moved along and received its priorities. About the time an "A" priority was received, some other project in the country would get an "AA" rating and the fight would begin all over again!

During one period when fighting for the necessary allocation of steel for the erection of the railroad high lines, one of the Government's representatives asked if Republic didn't produce concrete bars. When answered "Yes", he replied: "That is your answer. Build everything you can out of concrete." A visitor today therefore sees the high lines, fuel oil storage tanks, the coal mixing building, the coal storage building, the machine shop and electrical shop and their runways constructed of reinforced concrete. Even though galvanized sheets are marketed by Republic, the sides of the buildings are of Transite. Many were the arguments as to what constituted an "embellishment".

Early Operations

It will be remembered that ground was broken on Plancor 422 on Jan. 12, 1942. As 1942 drew to a close there arose an insistent demand to start production. Our furnaces could cast ingots long before the new rolling mills were ready. Could they be rolled in our old 35-in. blooming mill, alongside, to the south? Small ingots could of course be rolled, but they would have to be hauled about a half-mile.

It was also necessary to clear out the carpenter shop and put in metallurgical laboratory equipment with lathes, heat treating furnaces and Magnaflux. (This temporary laboratory was used until the new laboratory was ready in the fall of 1943.) It was also necessary to add burial pits and slow cooling furnaces in various locations in

the old plant to handle the steel that we expected to produce.

Figure 3 shows the appearance of the west or river end of the furnace building on April 3, 1943, when the first electric went into operation. (The second followed nine days later.) It can be seen that the operations were under some difficulties. We had to bring in a 500-kw. motor-generator set from the old Grand Crossing wire mill to supply d.c. energy to operate the cranes, to borrow a ladle crane from Republic's plant in Buffalo (and build a temporary runway for it of proper span). Two ladles were brought in from Buffalo and two were taken from the Chicago stationary open-hearth shop. An overhead floor crane was brought in from Canton, lengthened and placed on the charging floor runway. A charging car was brought in from the Cleveland District.

At the start of operations only the center portion of the openhearth and electric furnace buildings was completed and roofed. A ladder was the only access to the charging floor, so a steam crawler-type crane was rented for lifting the charging boxes of scrap and stone from flat cars on the ground level onto the charging floor where the overhead crane could set them on the charging buggies. There was not sufficient room to handle a full charge, so after charging half of a heat the overhead crane had to take away the empty boxes from the buggies and replace them with full ones.

These early heats were poured in molds on standard-gage railroad buggies. The old stripper building and soaking pits were serviced by narrow-gage equipment, so we extended the standard-gage to the old plant and laid a third rail along the narrow-gage tracks.

The chief metallurgist of the Chicago District tells a story which typifies the entire situation: A short time before we were ready to start up he and the author were inspecting the melt shop — as far as it had been completed — and it was mentioned to him that we would be tapping steel in three weeks. He said, "We can't tap steel without a chemical laboratory for preliminary tests." As he tells the story, my reply was, "That's why I thought I had better mention it." (As a matter of information, a temporary but complete chemical laboratory in miniature was set up on the floor, covered with tarpaulin and was ready in two weeks.) All of the things in this laboratory, with the exception of the drill press, had to be carried up the ladder by hand since the cranes were usually busy.

During the remainder of 1943 approximately 80,000 tons of electric furnace ingots were produced in these first two furnaces and rolled in the old plant. This added burden soon developed a bottleneck over there, particularly in the annealing pits and conditioning departments. To overcome this a Caterpillar crane was rented and served the pickling vat and the chipping skids, and loaded cars. Another pickling vat was moved out to the yard where it could be serviced by the gantry crane.

The first tilting openhearth furnace was charged on Oct. 21, 1943. Since the demands for steel were changing by this time and shell steel was a major requirement, this steel was put into ingots rather than charged into the electrics. During the balance of the year this furnace produced 20,529 tons.

The first ingot was put through the 44-in. blooming mill on Oct. 20, 1943, but necessary adjustments and corrections postponed the actual starting date three days. This mill rolled 27,961 tons of steel by the end of that year, operating on a single turn basis. The bar mill, due to difficulties in obtaining material and priorities, did not get into operation until June of 1944. Coal was first charged into the new coke oven battery on Aug. 3, 1944. The author of this paper had the privilege of applying the torch to the blast furnace at 2:00 p.m. on Aug. 8, 1944. This blast furnace produced 16,516 tons of iron by the end of that month.

While quoting statistics, it might be said that by Sept. 1, 1944, 198,517 tons of electric furnace ingots had been produced and 82% of the heats produced had been aircraft or large gun bloom heats, all of which had been urgently needed for the war program.

Some Production Matters

It is interesting to know that the thirteenth heat made in the electric furnaces was the first heat of aircraft quality steel and it was rolled into a variety of sizes from ⅝ to 2-in. rounds for various aircraft parts. Considerable discussion took place before we made up our minds to gamble on the thirteenth heat for this high-quality steel!

The first large spectrographic laboratory ever installed on a melt shop floor was put in, together with the regular laboratory for preliminary use. An interesting thing about this was the way the spectrograph was sold to the melters. At the outset preliminary tests were run both by spectrographic and wet chemical methods, and the results of both were reported to the melters. Gradually the melters came to realize that they

M. E. Goetz

A 1917 B.S. in Metallurgy from Penn State, World War Capt. Goetz at 24 years of age had already spent some time on the openhearth floor learning steelmaking. From third to second to first helper and finally melter at Aliquippa Works of Jones & Laughlin, in 1923 he became superintendent of rolling mills. In mid-1940 he joined Republic Steel Corp. as Chicago district manager, right at the beginning of the rat-race he describes in this article. Transferred to Cleveland at the War's end, he became manager of the Cleveland District, Republic Steel Corp., in 1952.

were practically the same and they finally said "Why not use the spectrographic laboratory preliminaries which can be run in a matter of 15 min. instead of waiting an hour and a half for the wet method?"

Large Gun Blooms

About the middle of March 1944, we were instructed to get into the production of large gun bloom heats as quickly as possible, and the first one was poured on April 1. As frequently happens, the gun blooms which were produced were considerably larger than originally anticipated and, of course, presented many complications. Tubes or barrels for the 150-mm. gun (the famous "Long Tom"), the 8-in. howitzer and the 4.5-in. gun were produced. They required bloom weights of 17,800, 18,000 and 7600 lb. respectively, using 34-in. square ingots. Long Tom needed an ingot nearly 13½ ft. high weighing about 33,000 lb.

To pour these large ingots we found we could use as the pouring platform the escape platform provided for the ladle cranemen in case of emergency. In other places along the production line we were not so fortunate; for example:

1. The entry to the soaking pit building, where the ingots are reheated for rolling, had to be increased in height in order to provide clearance for the long ingots.

2. Although the soaking pits had been built far deeper than usual, they still were too shallow. These long ingots had to be placed in the soaking pits with bottom end against one wall and top resting against the opposite wall, or in other words, criss-crossed.

3. Blooms had to be furnace cooled after rolling to avoid internal cracks or ruptures. The time required ranged from seven to nine days. To increase production we had to find additional means for slow cooling the blooms. Burying in slag was tried and this took from two weeks to 18 days to cool. Since the ten annealing furnaces were not being used, we found that each furnace

A. A. Claassen

In 1902, when Lackawanna Steel Co. was building its new steel plant at Buffalo, it employed a young field engineer named Claassen. He learned so well that he was engineer in charge of construction of the plant built at Sault Ste. Marie, 1910 to 1915. He served similarly for the first T.N.T. plant of World War I at Harrisburg, Pa., and right after the war joined the staff of Interstate Iron & Steel Co. This firm was bought by Republic in 1930, to become the Chicago District, and as chief engineer Mr. Claassen solved many of the extraordinary problems connected with Plancor 422.

would handle a heat of blooms. A railroad car with a layer of slag to insulate the car bottom from the heat and to avoid chilling the blooms, was used to haul the individual blooms as soon as rolled into the annealing building.

Some of the other problems met in the gun bloom program were as follows:

1. Slices from each end of each gun bloom had to be etched in hot hydrochloric acid to determine soundness. On the larger blooms, 23½ in. square, this slice weighed about 160 lb. To facilitate handling, they were nicked and broken into quarter sections. When the war was over 1900 tons of etch tests covering the gun steel production were held in storage until every detail of the gun bloom contract was settled and it was evident that no future claims would arise.

2. A test from each gun bloom heat had to be made to prove that the necessary physicals could be met. This test called for a 24 x 24 x 2500-lb. piece and these pieces were trucked to Canton, Ohio, where a large enough press was available to forge them into test pieces. Experience developed the fact that the same results could be obtained by pouring a smaller ingot and rolling to a 12 x 12-in. bloom (which gave the same amount of reduction as the large ingot to a 24 x 24-in. bloom); when the 12 x 12 was forged to muzzle dimensions the transverse physicals would correlate with the acceptance tests on the finished gun forging. We at South Chicago could and did forge these pieces, thereby eliminating the necessity for trucking to Canton with its corresponding delay.

At the start of the gun bloom program a man with a long scarfing torch was stationed at the exit end of the blooming mill tables, protected by asbestos clothing and looking like a man from Mars. The idea was for him to remove any surface breaks while the bloom was hot, but the blooms had such good surface that he was soon transferred to useful work elsewhere.

When our operating group saw the first cross-section etches made on the 24 x 24 slices, with the centers not too solid, all were very dubious of their success, having previously seen nothing larger than etched 12 x 12-in. blooms. When a gun steel expert from the Ordnance Department inspected the etches and reported that he was elated with the results, there was much relief in South Chicago! (The central portion of the bloom is removed before heat treating the final gun barrel.)

We had made 40 heats of steel worth about $2,000,000 before the first results came back from the plant forging the gun barrels! There is a lag of six months before the final physical qualities are available, and a much longer period before final proof firing.

In spite of the fact that production of gun tube steel represented a distinct departure from the usual practice, and that a number of difficulties were encountered, the Republic Steel Corp. has since been informed that the performance has been the best on record.

Some Business History

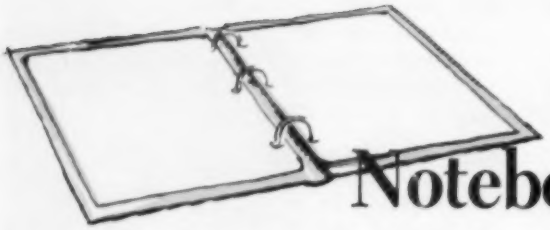
January of 1944 the Government decided that the Russians were badly in need of equipment and decided that the whole plant should be taken apart and shipped over there. We thought that it would be very wrong for the United States to permit a plant with the possibilities of this one to go to any foreign country. After much discussion it was decided to leave the plant in South Chicago.

Later on in the year, with the end of the war in sight, the Government decided to hold up completion, spend no more money on it, and to let it stand. However, when the cancellation charges were figured out it was found that they would be greater than the cost of completing the plant – so work continued.

As an indication of its value, during the extended steel strike in 1952 when the Government was deciding that it would operate certain plants, the South Chicago steel plant, erected during the war years as a war plant, was selected as one of the plants to be so operated.

The War Assets Board had put up this plant for sale and on Jan. 17, 1946, Republic Steel Corp., being the high bidder, became the owner. The contract of sale contains a defense clause along the following lines: "For a period of ten years, Republic Steel Corp. agrees to make no material alterations to structure of buildings or production equipment, which would permanently lessen productive capacity of the plant as it existed on Jan. 1, 1947, without prior approval of the War Assets Administration."

Since you have stayed with me to this point, it is hoped that you have an idea of the trials and tribulations of building a wartime plant for specialty steels. To build one is one thing, but to have to weave one into the operation of a then-going plant was a real experience. It was a personal privilege to have had a hand in it. As one of the men remarked "You really don't get the feel of a steel plant until you have had a part in the construction of one."



Notebook...

Dehomogenization of Solid Solutions

*By L. COLOMBIER**

IT IS GENERALLY considered that holding a solid solution at high temperature induces homogenization because the dissolved elements, which are originally distributed more or less uniformly, diffuse through the solid solution. It has also been thought that a spontaneous segregation of certain constituents can occur which results in a true "dehomogenization" of the alloy, particularly in steels.

The Swedish metallurgist Benedicks proposed in 1938 that the grain boundaries could be considered as phase limits and that, as shown by Gibbs, variations of concentration could be produced by positive or negative adsorption of dissolved elements. He used this theory to explain the influence of aluminum on grain growth in steel, assuming that aluminum nitride was concentrated by this mechanism at the grain boundaries of the steel.

I employed this hypothesis in 1945 and 1946 to explain the phenomenon of overheating and temper brittleness, a phenomenon which could only be explained by the retention of austenitic grain boundaries in the martensite. This results in the steel having a "double structure" that consists of a persistent network of austenitic boundaries superposed on the martensitic structure.

When a nickel-chromium-molybdenum steel is quenched after overheating at 2280 to 2370° F., the large intergranular crystals characteristic of overheating are revealed in fracture specimens, with the fracture being often completely intergranular. After the usual restoration treatments, such as tempering at 1650° F. followed by normal quench at 1560° F. and tempering at 1110° F., the intergranular fracture characteristic of overheating gives way to a normal fracture of the "fibrous" type. However, when the steel is sensitive to temper brittleness, the tempering at 1110° F. need only be followed by a slow cooling or by a second prolonged tempering in the sensitive zone (for example, at 975° F.) to again obtain an intergranular fracture having the same grain size as before the restoration treatments. Evidently the network induced by overheating persisted at least partially in the restored metal; it was not apparent but was indicated by temper brittleness as revealed by the fracture.

These ideas have since been considered in some detail in both British and French publications. While I will not insist on the application of the Gibbs law of positive or negative adsorption in grain boundaries, this theory has been referred to by J. W. Spretnak and R. Speiser (*Transactions* ASM, Vol. 43, 1951, p. 734.), who thus revert to ideas proposed in France five years ago. There is no doubt that the theory can be the basis for a satisfactory explanation of the phenomenon of overheating and temper brittleness.

The profound importance of this theory of "dehomogenization" is evident in other instances. Thus J. Hochmann could show that carbon segregation occurs in the grain boundaries of ferrite with 25% chromium treated at 2190° F. The iron-chromium alloy was of high purity and contained only 0.04% carbon. After heating at 2190° F. carbon enrichment of the grain boundaries was so great that the structure at the boundaries became austenitic. An actual network of austenite was formed around the ferrite grains, visible on a micrograph as a distinct phase in the boundary.

*Chief Research Engineer, Compagnie des Ateliers et Forges de la Loire, Unieux, France.

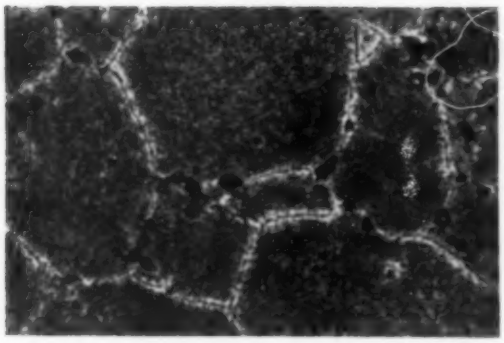


Fig. 1 – An 18-8 Stainless Steel With 0.6% C, Heated to 2280° F., Water Quenched and Tempered at 1380° F. to Induce Carbide Precipitation. Positive adsorption of carbon in the grain boundaries causes decarburized white zones alongside. Electrolytically polished and etched with oxalic acid. 500 ×

As a result of the much greater solubility of carbon in the austenite, there appeared also on either side of the boundary a sizable decarburized zone, which was white on the micrograph in contrast to the interior of the grains, where the presence of carbon gives a veined structure.

The same white zones are observed along the boundaries of a carburized austenite treated at high temperature. The positive adsorption of carbon in the boundaries impoverishes the contiguous area where the carbon content falls below the limit of solubility. The structure in Fig. 1 is typical in this respect. The alloy shown, an 18-8 stainless steel with 0.6% carbon, was heated to 2280° F., water quenched, and then tempered at 1380° F. to induce carbide precipitation. The white zones along the boundaries appear very clearly.

It seems to me and to my collaborator J. Hochmann ("Intergranular Corrosion of Stainless Austenites", *Comptes Rendus*, July 9, 1951) that this same carbon segregation in grain boundaries provides an explanation for the susceptibility to intergranular corrosion of this type of steel. Spretnak and Speiser, as well as Zapffe in his comments on their paper, also thought of this explanation. Indeed, if the homogeneity of the initial austenite be granted, it would be difficult to explain how a very short time of holding at high temperature (as in arc welding) could cause carbon and chromium to diffuse speedily enough to make the metal susceptible. However, if the austenite is heterogeneous and if the carbon is already concentrated in the boundaries, it can precipitate where it is without having to diffuse. In the very first phase of the phenomenon, this precipitation can occur either in the form of chromium carbide at the expense of the chromium in the immediate neighborhood, or in the form of iron carbide or even of carbon, the great corrodibility being explained by the state of tension provoked by this precipitation. It is only during prolonged holding that the chromium can diffuse, as the result of a change in the equilibrium due to the initial precipitation. The hypothesis of "dehomogenization" thus avoids one of the weaknesses of the theory of chromium depletion.

The same theory can also explain numerous observations in other fields.

Thus the spread at the beginning of the martensitic transformation is explained by the heterogeneity of the metal, a heterogeneity which increases with the heating temperature before quenching. C. Crussard ("Semaine d'Etudes de la Physique des Metaux", Paris, July 1948, p. 49) attributed this heterogeneity to fluctuations in composition due to thermal effects. Perhaps it is the result of positive or negative adsorption in the grain boundaries and at imperfections in the network.

The same explanation can account for the fact that the quantity of residual austenite after quenching increases when the austenitizing temperature increases, even above the temperature where the dissolution of carbides is completed. W. J. Harris, Jr. and M. Cohen (*Metals Technology*, September 1948) demonstrated that when the austenitizing temperature of a 1.1% carbon steel was raised above 1500° F., the quantity of residual austenite doubled. This phenomenon is reversible and if, after the steel is heated to a high temperature, it is quenched at the normal temperature, the initial quantity of residual austenite is recovered, which shows that grain growth is not a determining factor. Harris and Cohen explain the phenomenon by the fluctuations of concentration which decrease at high temperature and are thus the opposite of those described by Crussard. We think that these heterogeneities can be easily explained without such contradictions by the positive or negative segregation of certain elements, as much in the grain boundaries as on the scale of the mosaic structure and in various network imperfections.

Thus, the theory of dehomogenization of solid solutions, which already explains several phenomena, seems to offer many other interesting possibilities.

Correspondence

A Job for A.S.M.

SPRINGFIELD, OHIO

The Industrial Heating Panel Discussions held at the National Metal Congress on Tuesday, Nov. 3, 1954, were excellent in their exposition of the advances in furnace atmosphere generation and atmosphere applications. The great advances made by the furnace manufacturers seem, however, to pose a problem that we, in the ⊕, may be required to solve. The problem is the measurement of carburized case depth.

To define the problem, we will be required first to define what *is* carburized case depth. Do we mean *total* case depth, in which the total thickness of case above the base carbon content is measured? Or do we mean *effective* case depth, which is measured from the surface to some arbitrarily selected end point. The distinction is important, as Mr. Holcroft pointed out in his paper, "Elements of Gas Carburizing". (See *Metal Progress* for November 1954, p. 106.) The time required to establish an effective case depth is in excess of that required for total case depth by an amount dependent, first, upon the steel being carburized, and second upon the depth of the case that is actually desired. For instance, the effective case depth established in A.I.S.I. 9310 steel is less than in 4620 steel when the carburizing time is the same; in addition, the transition zone (which is a factor in effective case measurement) between case and core is larger as the carburizing time is increased.

The retort may reasonably be, "So what?" Why not use the total case depth as the criterion of measurement, if effective case measurement is such a variable? Why not, indeed, except that the designer is primarily interested in a load-bearing case of certain thickness. The use of total case as a criterion does not satisfy this requirement because not all of the total case will harden sufficiently to carry its share of the load. Hence the metallurgist and metallurgical engineer have come more and more to rely on the concept of "effective" case depth.

Well, how can we measure effective case depth? Basically, by hardness – that is, the depth that will harden to a certain minimum hardness. Since, however, measurement of this hardness is dependent upon instruments and techniques that are highly precise, the measurements must be done in a well-equipped laboratory. (See ⊕ Metals Handbook, 1948 edition, p. 686.) Various expedients have been evolved to check the effective case on a routine control basis. Three of these are outlined below; there are undoubtedly others.

One method is to prepare a hardened specimen by cutting a cross section and polishing it. This is then etched and examined through a Brinell microscope. The effective case is read to the middle of the transition zone. The second method is intended to be a refinement of the first, in that a higher polish and a higher magnification are employed. Actually, only a highly trained observer can estimate the precise center of the transition zone at this magnification – and agreement between observers is not good. This may be due to a compulsion on the part of the heat treater to read high and on the part of the control technician to read low. The third method is that outlined in *Metal Progress* for December 1953 ("Measurement of Case Depth"). It is a fracture-etch test in which close agreement is obtained in repetitive readings by different observers.

It appears that some standardized method for measurement of the effective carburized case depth is needed. With the method standardized, it will be possible to eliminate a source of contention between the heat treater and the user of the carburized part. It appears that this standardization can be most effective when sponsored by the ⊕. What will we do about it?

JOSEPH J. WARGA
Chief Metallurgist
Steel Products Engineering Co.

Defines New Terms

EDITOR'S NOTE: New terms, especially technical terms, have a way of suddenly cropping up and, it seems, just as suddenly acquiring popular usage. "Chi phase" and "Laves phase" are good examples. Because these have appeared in a number of reports and articles and concise definitions (if such have been published) have escaped our notice, we asked H. J. Beattie to define these terms which he used in the paper he presented at the last National Metal Congress.

West Lynn, Mass.

The term "Laves phase" applies to any of three lattice structures which have a common packing principle. This principle is the close packing of spherical atoms of two different sizes. The Laves phases have the formula AB_2, where A is 20% to 30% larger in atomic diameter than B.

The three lattice structures are referred to as the $MgZn_2$ type (hexagonal), the $MgCu_2$ type (cubic), and the $MgNi_2$ type (hexagonal). They differ only in the stacking order of the hexagonal layers. These three structures have been observed in dozens of binary, ternary and quaternary alloy systems.

"Laves" (pronounced lah'vez) is the name of the man who first recognized the relation between these three structures (F. Laves and H. Witte, *Metallwirtschaft*, Vol. 14, 1935, p. 645). The term "Laves phase" was apparently first coined by the German colleagues of Laves. The term has crept into English technical literature only recently, and it can be found in at least two books ("Progress in the Theory of Alloys", by G. V. Raynor, "Progress in Metal Physics", 1950, Interscience Publishers, p. 34 to 39; and "Structure of Metals", by C. S. Barret, 2nd edition, 1952, McGraw-Hill Book Co., p. 240 to 241).

Chi phase may be defined as a solid solution of transition metals having the alpha-manganese structure. The complicated structure of alpha-manganese (the cubic unit cell contains 58 atoms) was solved in 1927. In 1949 Andrews reported that an intermediate phase precipitating in chromium-nickel-molybdenum steels had the alpha-manganese structure and designated it "chi phase" (K. W. Andrews, *Nature*, Vol. 164, 1949, p. 1015). This designation has stuck.

The following short definitions are adequate:

Laves phase – An intermediate phase having one of the three related lattice structures of the type $MgZn_2$, $MgCu_2$ or $MgNi_2$, each structure being appropriate for the closest packing of spherical atoms of 20% to 30% size difference (after Fritz Laves, who was the first to recognize this relationship).

Chi phase – An intermediate phase having the alpha-manganese lattice structure; the term is presently restricted to alloys of transition metals of the first long period and molybdenum.

These terms have probably not been in use long enough to appear in dictionaries, but we are certain that they soon will.

H. J. Beattie
Thomson Laboratory
General Electric Co.

Quench and Work Technique

Rehoboth, Mass.

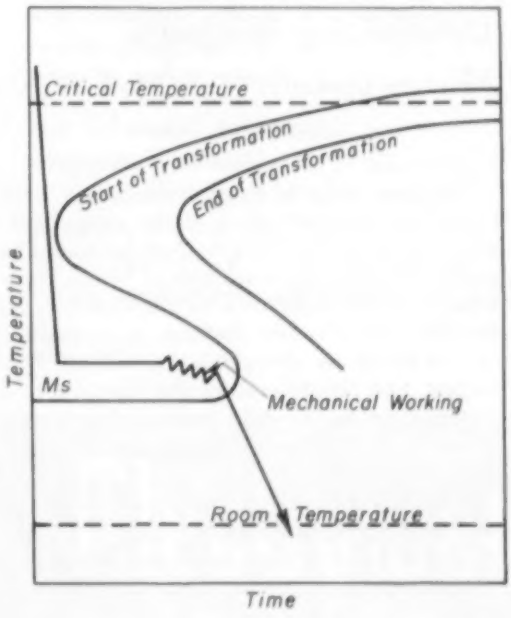
The writer has noted an article entitled "Improved Hardening Technique" by Messrs. Lips and Van Zuilen in the August issue of *Metal Progress*. The authors report that yield and elongation of steel – specifically a 4.5 Ni, 1.5 Cr, 0.35 C steel – are greatly improved over those achieved by ordinary quenching and tempering if the metal is rapidly quenched and worked as shown in my diagram below.

It is a source of satisfaction to learn that the Dutch investigators confirm my own investigations. I have used this treatment for several years with successful results. The "interrupted-quenching mechanical-working" technique was developed by me as an improvement over the basic "step-quench treatment" (later designated martempering), which, as far as I know, was first used for hardening hacksaws through my efforts starting in 1938.

It is unexpected that this method (the interrupted-quenching mechanical-working treatment) should appear as a "new" development, since it was adequately described in *Iron Age* of Dec. 27, 1951, as well as other journals here and abroad. The diagram appeared in such disclosures, and the technique is covered by patent applications.

Richard F. Harvey

Diagram Representing Technique of "Interrupted-Quenching Hot-Working"



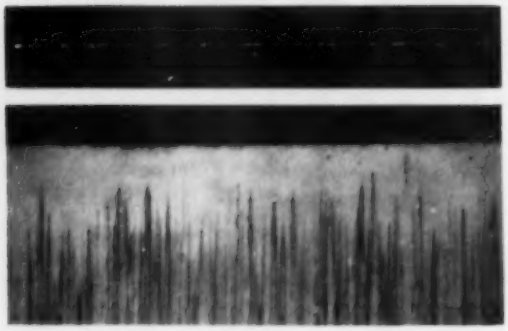


Fig. 1 – Cutting Edge of Good Quality Razor Blade (Top, Edge-on; Lower, Profile). Load to cut string 110 to 164 g., average 130 g. (eight tests). 500 ×

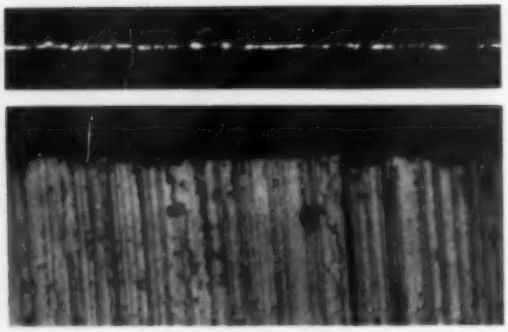


Fig. 2 – Cutting Edge of Surgical Scalpel; Note "Saw-Tooth" Edge Produced by Coarse Grinding. Load to cut string, 140 to 290 g., average 194 g. (nine tests). 500 ×

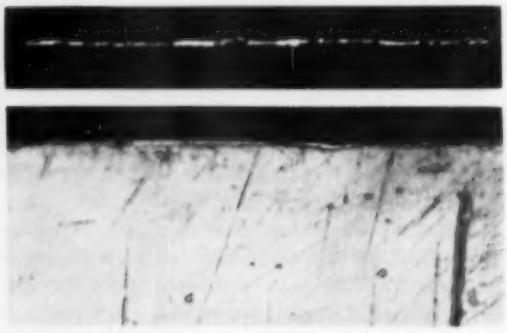


Fig. 3 – Cutting Edge of Surgical Scalpel Blunted by Use. Load to cut string 320 and 310 g. (two tests). 500 ×

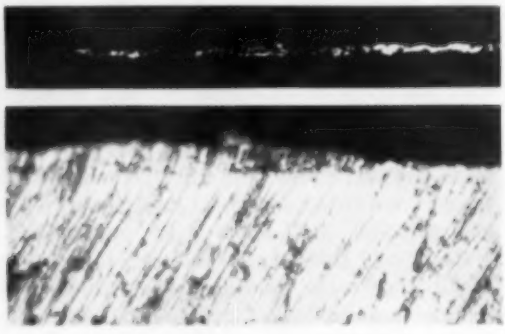


Fig. 4 – Cutting Edge of Surgical Scalpel Resharpened by Hand. Load to cut string 194, 285, 218 and 250 g. (four tests made close to position shown in profile view). Note "feather edge" which is half broken off (bending out of focus). 500 ×

Determining Sharpness Microscopically

MELBOURNE, AUSTRALIA

The issue of *Metal Progress* for March 1954, containing the description of the razor blade sharpness tester (p. 112) devised by Kawakita and Iwase of the Japan Institute of Metals, came when work was being done in this laboratory on the influence of various methods of sterilization on the sharpness of surgical instruments. The method used here to evaluate the sharpness of a cutting edge was by microscopical examination of the edge at 500 ×, in profile and edge-on, under vertical illumination.

A simplified version of Iwase and Kawakita's string-cutting apparatus was devised – a gradual loading of a pan with fine sand being substituted for the water-level method of forcing the blade against the string – and used to test cutting edges which had been examined microscopically and photographed. The results obtained (load in grams to sever cotton thread) are given beneath the accompanying micrographs of representative types of edges examined. It will be seen that the results of the string-cutting test, as shown in the captions, are in accord with the microscopical appearance of the edges.

The microscopical method is rapid and free from the variables that must accompany the use of the string-cutting apparatus. The quality of the entire length of the blade can be ascertained, and undesirable features such as "sawtooth" edges and unstable "feather" edges are immediately apparent (see Fig. 2 and 4).

P. W. GOAD
Division of Industrial Chemistry
Commonwealth Scientific and
Industrial Research Organization

Improve ladle additions of chromium to steel with ELECTROMET Exothermic Ferrochrome

LOW CARBON PICKUP

ELECTROMET Exothermic Ferrochrome 8, which has a 12 to 1 chromium-to-carbon ratio, gives a carbon pickup of 0.08% for each per cent of chromium added. ELECTROMET's new Exothermic Ferrochrome 5, having a 20 to 1 chromium-to-carbon ratio, gives only about 0.05% carbon pickup for each per cent of chromium added.

HIGH CHROME RECOVERY

About 92% of the chromium is recovered regularly. This provides close control of chromium specifications in the finished steel with a minimum loss of alloy.

FAST SOLUBILITY

ELECTROMET exothermic ferrochrome generates the right amount of heat to melt the alloy quickly and prevent chilling the metal in the ladle.

Other advantages of ELECTROMET'S Exothermic Ferrochrome:

High ignition temperature (above 750 Deg. F.) gives maximum protection against fire hazard during storage.

For convenient, easy handling the alloy is packed in cans, or in strong, flameproof and moisture-proof bags. Cans or bags are shipped on pallets at customer option. Each pallet holds 60 cans or 80 bags.

No weighing is necessary since each can or bag holds exactly 25 lb. of contained chromium. Just count the cans or bags to obtain the weight desired.

FREE TECHNICAL ASSISTANCE . . . in the use of the material is furnished by ELECTROMET's experienced field representatives. Further information will be gladly furnished on request. Please contact one of the offices listed below.

The term "Electromet" is a registered trade-mark of Union Carbide and Carbon Corporation.

ELECTRO METALLURGICAL COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

OFFICES: Birmingham • Chicago • Cleveland • Detroit
Houston • Los Angeles • New York • Pittsburgh • San Francisco

In Canada: Electro Metallurgical Company, Division of Union Carbide Canada Limited, Welland, Ontario

Electromet

TRADE MARK

Ferro-Alloys and Metals

Personal Mention

F. P. Zimmerli

Maurice J. Day

F. P. ZIMMERLI is the new director of engineering and research at Associated Spring Corp., Bristol, Conn. Graduating from the University of Michigan with bachelor of science and master of science degrees in chemical engineering and metallurgical engineering, Mr. Zimmerli has been a member and officer of numerous engineering and technical societies and groups. After graduation from college he spent two years in teaching metallography and metallurgy at his alma mater. He then served as metallurgist for the Solvay Process Corp. for one year, after which he was research metallurgist at Dodge Bros. Corp., going from there to Rickenbacker Motor Co., where he was chief metallurgist. For the past 28 years he has held the position of chief engineer for the Barnes-Gibson-Raymond Div. of Associated Spring Corp. A member of the American Society for Metals since 1921, he has served the Detroit Chapter as secretary-treasurer, vice-chairman, and chairman. He received the Sauveur Achievement Award in 1947, and in 1951 was called upon to deliver the William P. Woodside Lecture for the Detroit Chapter. Mr. Zimmerli is an active member of the Society of Automotive Engineers, American Society for Testing Materials, and the Engineering Society of Detroit.

MAURICE J. DAY has been appointed director of research and development for Crucible Steel Co. of America, Pittsburgh. Dr. Day graduated from Michigan State College with a B.S. degree in chemical engineering in 1934. In 1935 he received an M.S. degree in electrochemistry, and in 1937 received his doctorate in physical chemistry from the same institution. He began his career as a metallurgist with Carnegie-Illinois Steel Corp. (now part of United States Steel Corp.) at Gary, Ind., in 1937, serving in various capacities until 1952, when he resigned as assistant metallurgical engineer for alloy steels at the Corporation's Pittsburgh offices. He then became manager, materials and processes division, Armour Research Foundation of Illinois Institute of Technology. The next year he was named assistant director for program development, the position he held until his present appointment. Listed in "American Men of Science" and "Who's Who in Commerce and Industry", Dr. Day has been active in the National Academy of Sciences on the Materials Advisory Board as chairman of the manganese panel and as a member of the panel on guided missiles. Dr. Day's memberships include the American Institute of Management, American Institute of Mining and Metallurgical Engineers, American Management Association, Institute of Metals (British), and Society of Automotive Engineers. He holds a patent on a method of production of thermally hardenable boron-titanium steels, is co-holder of a patent covering a method of making low-alloy steel, and is the author of a number of technical papers and publications in his field.

Eugene H. Smiles, who received the bachelor of science degree in metallurgical engineering from the University of Alabama in August 1954, has accepted a position as metallurgist in the metallurgical laboratory of Crucible Steel Co. of America, Harrison, N.J.

Wiley E. Pruner is now associated with the advertising agency of Rossi and Co., Detroit, as an account executive in charge of industrial accounts.

D. L. Younie, formerly furnace and plating engineer at Wright Aeronautical Corp., Wood-Ridge, N.J., is now plant superintendent of White Heat Treating Co., Huntington Park, Calif.

Craig Malin is now attending the Harvard Graduate School of Business Administration.

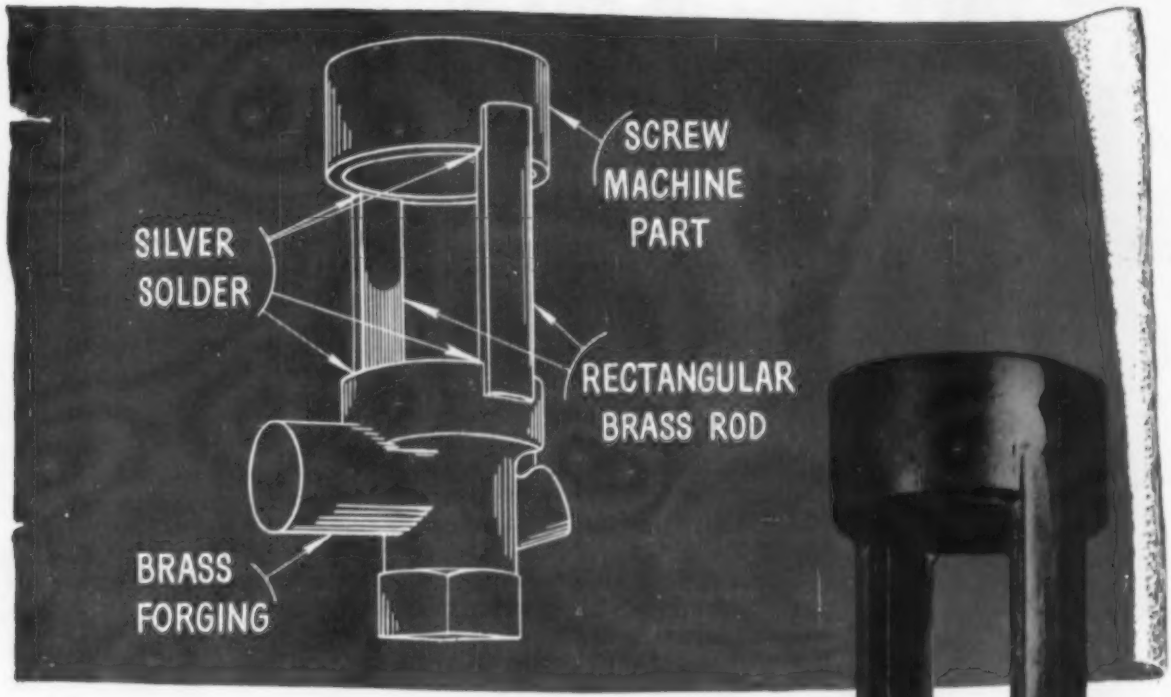
Robert S. Neilson has resigned as tool engineer for Scaife Co., Oakmont, Pa., and is now employed as sales engineer for the Hydraulic Press Div. of Baldwin Lima Hamilton Corp. with headquarters in Eddystone, Pa.

W. P. Achbach is now principal metallurgist in the applied mechanics division at Battelle Memorial Institute, Columbus, Ohio.

J. N. Ramsey, having finished his work at Rensselaer Polytechnic Institute and spent a year at the Air Reduction Research Laboratory, Murray Hill, N.J., is now a senior research engineer in the welding section, department of metallurgy, Massachusetts Institute of Technology.

Albert A. Averbeck, an employee of the Hussmann Refrigerator Co., St. Louis, for the past 15 years, is now with the sales organization of General Electric Co.'s welding division in Houston, Texas.

REVERE Brass Forging



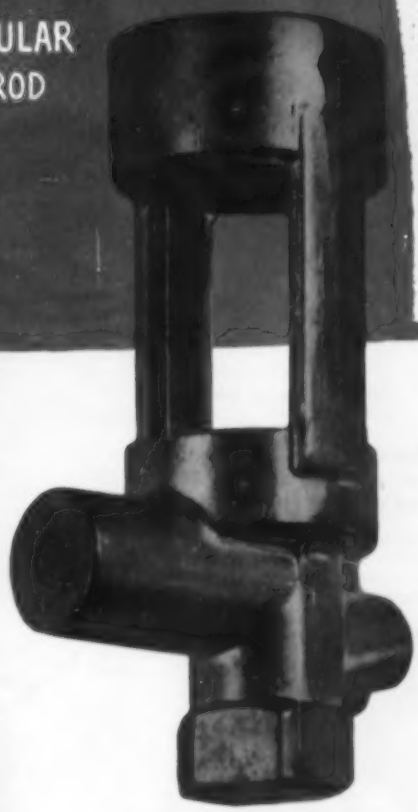
MAKES 1 PART OUT OF FOUR

. . . saves money

The one-piece brass forging shown here replaces a built-up part, formerly made of a screw-machine part, a forging, and two rectangular bars, assembled by four silver-soldered joints. The latter in turn replaced an iron casting, which was more expensive than expected, due to rejects. The part goes into a visible force-feed lubricator, which can operate at several thousand psi., and can be controlled to feed just a drop at just the right time to such equipment as compressors.

We suggest you look into forgings of copper, brass, other copper alloys, aluminum alloys. The forging process produces parts that are dense, non-porous, have many design details accurately and smoothly executed, require a minimum of machining. Revere knows a great deal about the forging of non-ferrous metals. In the case shown here, we collaborated closely with the customer in designing the part so it could be forged in one piece instead of being assembled out of four different items. The result is a better part, and appreciable economies.

For information about forgings, see the nearest Revere Sales Office.



Partially-machined brass forging for sight feed of force-feed lubricator.

At top, drawing showing how this part formerly was assembled out of four different pieces.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N.Y.

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.— Sales Offices in Principal Cities, Distributors Everywhere.

Personals . . .

George J. Chris has been appointed assistant group leader in charge of material laboratories at Douglas Aircraft Co., El Segundo, Calif.

Frank J. Gallagher, former production engineer with Given Mfg. Co., is now general manager of Ryder-Elliott Co., Los Angeles.

Joseph I. Farmer, previously employed as chief engineer for Ferro Powdered Metals, a subsidiary of the Ferro Corp., is now manager of the powder metal department at Ford Motor Co., Dearborn, Mich.

Donald D. Russell has been transferred by the Minneapolis-Honeywell Regulator Co. from Minneapolis to Des Moines, Iowa, continuing his work as application engineer of industrial instruments.

Howard H. Casey, formerly general sales manager, is now director of sales of the Midvale Co., Philadelphia.

Lorin L. Ferrall, previously assistant vice-president of operations of Crucible Steel Co. of America, has been elected vice-president of operations. **James D. Glenn**, former product manager of stainless steel sales, has been appointed general manager of sales and will be responsible for directing company-wide sales activities for Crucible. **George W. Stamm**, formerly assistant to the vice-president of sales, is now assistant general manager of sales. Mr. Ferrall joined Crucible as director of metallurgy in 1945, after serving in metallurgical positions with various companies in the steel industry. A graduate of Carnegie Institute of Technology, he is also a vice-president and director of vacuum Metals Corp. Mr. Glenn has specialized in stainless and alloy steel sales activities since entering the steel industry in 1927. He joined Crucible as product manager of stainless steel sales after holding sales and sales administration positions in several specialty steel companies. Mr. Stamm joined Crucible as a sales trainee in 1940. He has since served the company as a tool-steel service engineer, assistant sales branch manager, and sales branch manager. In 1952, he was named assistant to the vice-president in charge of sales. He is an engineering graduate of Washington University of St. Louis.

George A. Elliott was elected vice-president and general manager of Robertshaw-Fulton Controls (Canada) Limited. Mr. Elliott is in charge of the company's new Toronto manufacturing plant. He was previously national manager, apparatus and supply, of the Canadian Westinghouse Supply Co. Earlier in his career he was general manager of the Kearney Corp., Guelph, Ont., and served with Canadian Line Materials, Scarboro, Ont. Mr. Elliott holds a degree in electrical engineering from Durham University, Durham, England.

Richard B. Smith has been promoted to sales engineer by the Electro-Alloys Div., American Brake Shoe Co., and assigned to the New York office of the company.

Test — and be *sure* your material is . . .

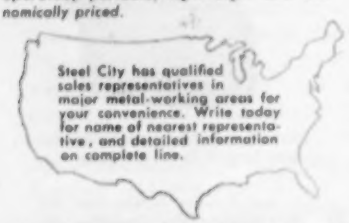
You save metal and manpower by testing for drawing qualities and stretcher strain.

Tests thickness to ¼" for drawing ability . . . capacities up to 40,000 lbs. Simplified hydraulic controls. Widely used for steel and non-ferrous sheets and strips.

(CUP-TEST)

Quick yet non-destructive method to determine sheet metal suitable for forming parts . . . and need for roller levelling. Hand operated, portable, lightweight and economically priced.

(FLEX-TESTER)


Steel City has qualified sales representatives in major metal-working areas for your convenience. Write today for name of nearest representative, and detailed information on complete line.

Manufacturers of machines for testing physical properties of metals, including:

Steel City Testing Machines Inc.

8811 Lyndon Ave. Detroit 38, Mich.

. . . and Special Testing Machines.

PSC *"Light Weight"* ANNEALING BOXES CUT HANDLING AND HEATING TIME

Left, a battery of 3 HOLCROFT overhead malleablizing furnaces at a large midwest foundry. Above, PSC boxes on the floor level, ready for elevating into a furnace.

Designed for use with conveyor-fed furnaces, the above PSC "Light-Weight" annealing boxes handle rapidly and easily through any load, unload, transfer or switch movement possible on a 90° conveyor.

Weighing only a small fraction of their 500-lb. load, these PSC "Light-Weight" containers not only save handling time but also effect impressive savings in heating time and fuel. Size 24" x 24", they are pinned to trays fitting roller rails. Fabricated of the sheet alloy which best stands the atmosphere and temperature conditions, these boxes have been in continuous 60-hour anneals for a great many months without significant distortion or embrittlement. PSC sheet alloy equipment fabricated for every purpose: annealing and carburizing boxes, covers, baskets, fixtures, retorts, tubes, etc.

Send for Heat Treating Catalog 52

A new standard reference

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

Personals . . .

R. R. Netoskie, a graduate of the University of Pittsburgh in June 1954 with a B.S. degree in metallurgical engineering, is now an engineering trainee with Rem-Cru Titanium Corp., Midland, Pa.

R. S. Aikenhead is now chief tool engineer for Scaife Co., Oakmont, Pa.

Lewis F. Herron, president of the James H. Herron Co., Cleveland (past chairman of the Cleveland Chapter), is the newly elected president of the American Council of Independent Laboratories, Inc. Mr. Herron is also active in the American Foundrymen's Society, American Institute of Mining and Metallurgical Engineers, Ohio Society of Professional Engineers, and the Society for Experimental Stress Analysis.

Leslie Clifton Whitney, manager of development engineering of Copperweld Steel Co., wire and cable division, Pittsburgh, has been elected president of the Wire Association. Mr. Whitney, a past chairman of the Pittsburgh Chapter, has been associated with Copperweld Steel Co. since 1930. He is a metallurgical engineering graduate of Lehigh University.

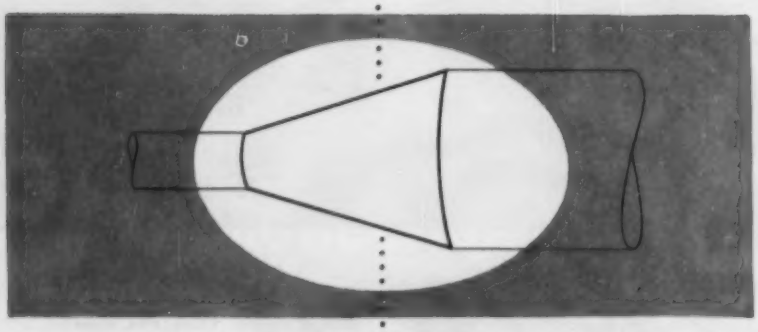
H. W. Cooper, for the past seven years development metallurgist for Superior Tube Co., will head the new mechanical development division at the Norristown, Pa., plant. Mr. Cooper is a graduate of Tri-State College of Engineering, Angola, Ind., with a degree in chemical engineering.

Robert K. McKechnie has been named unit manager of the newly established materials application unit in the metallurgy department of the General Electric Research Laboratory, Schenectady, N. Y. Mr. McKechnie has been with G.E. since 1947, serving at Knolls Atomic Power Laboratory and with the Carboloy department before becoming a research associate in the materials and processes section of the G.E. Laboratory in 1952. A graduate of Amherst College, he received his master's degree in metallurgy at Carnegie Institute of Technology.

William C. Beck has been promoted to assistant manager of the New York district sales office of Sharon Steel Corp. He began his employment with Sharon Steel as a metallurgical trainee in 1949, and until his present promotion has been a sales engineer with the Mallory-Sharon Titanium Corp. of Niles, Ohio. He has also been associated with the sales departments of two of Sharon Steel's divisions, the Detroit Tube and Steel Div., and the Sharonsteel Products Div. of Dearborn, Mich. Mr. Beck is a graduate of Rensselaer Polytechnic Institute.

Donald M. Hanson has been appointed a vice-president in charge of merchandising at Hubbell Metals, Inc., St. Louis, Mo. He has been associated with the company for fourteen years, and in addition to his new duties will continue as manager of the brass and copper department.

TITUSVILLE FORGED PIPE REDUCERS



Meet All Requirements for Industrial Piping Systems

Bench machined to your most exacting requirements—Titusville Forge pipe reducers can be furnished in carbon or alloy steel—for every industrial piping system. Bevels are machined to special sizes for welding. Hollow bored pipe and fittings also can be supplied in carbon, stainless steel or other alloys.

Latest manufacturing techniques and newest cost-saving methods are employed at Titusville Forge. Our long years of experience, modern fabricating facilities and special knowledge of design are your assurance of dependability in forgings to meet your requirements.

Struthers Wells

STRUTHERS WELLS CORPORATION

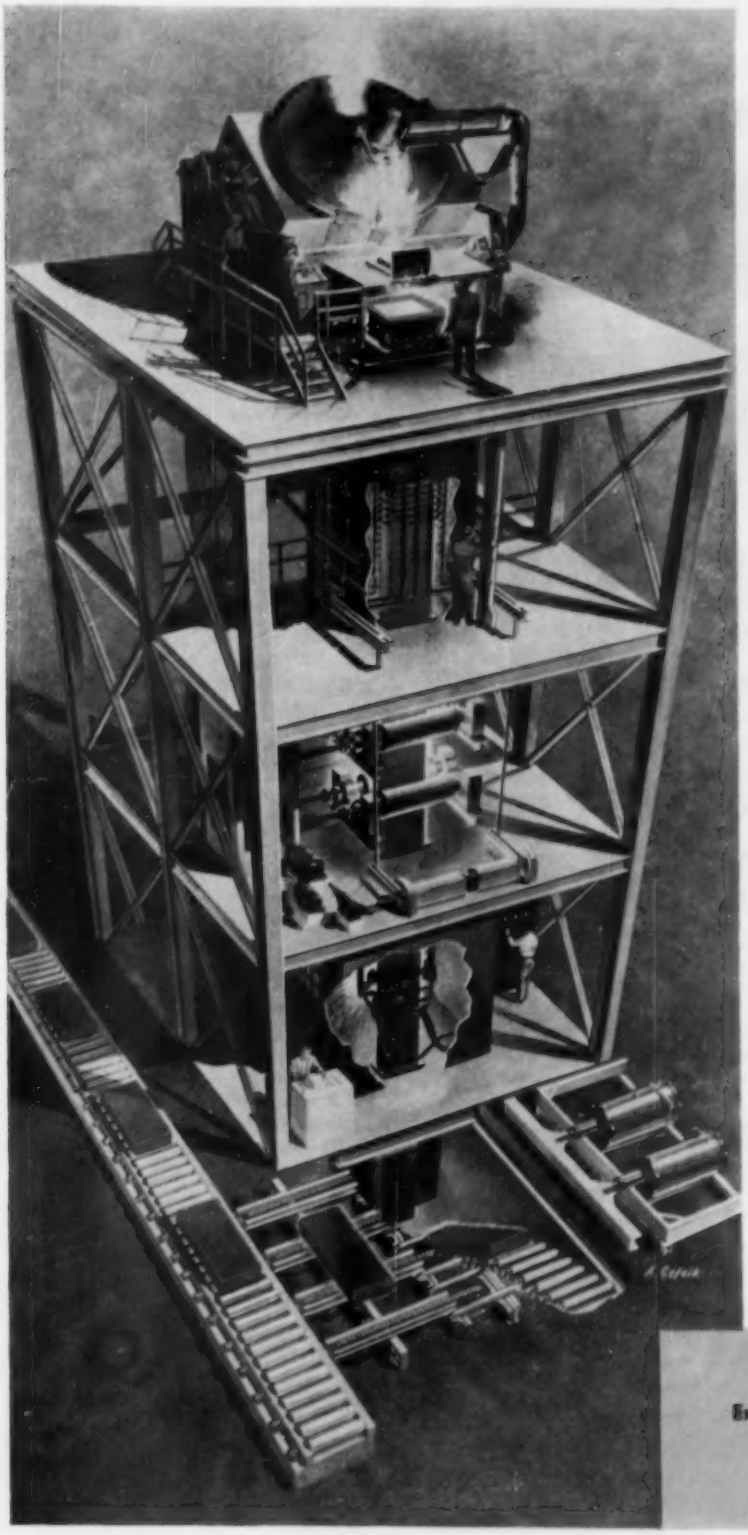
TITUSVILLE FORGE DIVISION

TITUSVILLE, PA.

PLANTS AT TITUSVILLE, PA., and WARREN, PA.

Offices in Principal Cities

For the continuous casting of steel...



Koppers builds the first commercial-scale machine

The continuous-casting machine illustrated here is now in operation at Atlas Steels Ltd., Welland, Ontario, Canada. This is the first commercial-scale installation in North America that, in a continuous line, converts molten steel into solidified billets or slabs. It was designed and constructed by the Freyn Department of Koppers Engineering and Construction Division.

Atlas Steels' machine is presently producing slabs and billets in three sizes. With different molds, this machine also could produce any desired billet section. It is designed to cast 35-ton heats.

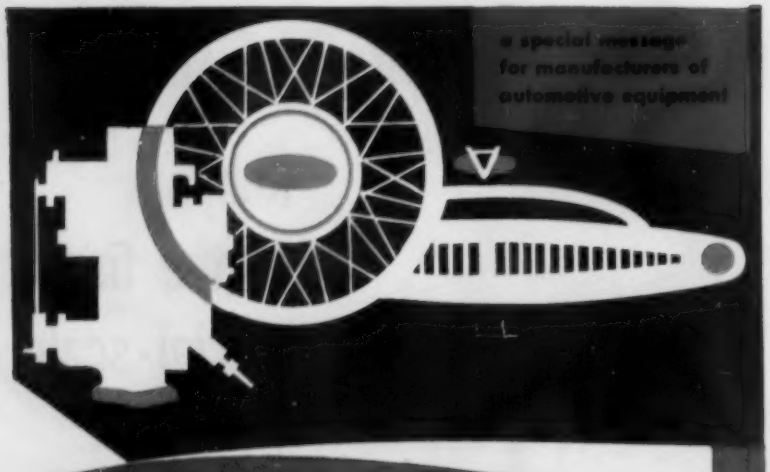
In theory, this new machine could cast a billet or slab of steel many miles in length; it is limited only by the supply of molten metal. In actual practice, acetylene torches automatically cut the molded steel into required lengths as it emerges from the machine.

Continuous casting is an *economical* short-cut in steelmaking. It eliminates the need for ingot-casting and stripping equipment, except the ladle crane. Soaking pits and blooming mills can be by-passed. Also, the Freyn-design continuous-casting process can yield 10 to 15 per cent more finished steel per heat than conventional pouring methods.

Your inquiry is invited concerning the continuous-casting operation . . . or any other metallurgical construction problems you may have. You incur no obligation.

KOPPERS®

KOPPERS COMPANY, INC.
Engineering and Construction Division
FREYN DEPARTMENT
Pittsburgh 19, Pennsylvania



need a finish for low cost corrosion protection or showroom sparkle?

specify IRIDITE

Whether you're finishing non-ferrous parts for high corrosion protection, paint base, or for showroom sales appeal, you can be sure of low material and production costs and peak performance when you specify Iridite. Here's what you can do with Iridite:

- **ON ZINC AND CADMIUM** you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.
- **ON COPPER . . .** Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.
- **ON ALUMINUM** Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.
- **ON MAGNESIUM** Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

Iridite is approved under government specifications

ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD

Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals, ARP Plating Chemicals.

Personals . . .

H. E. Fuhrmeister, formerly with National Lead Co., Sayreville, N.J., is now on the technical department metallurgical division staff of Titanium Metals Corp. of America, Henderson, Nev. **Ray. S. Richards**, formerly with Armour Research Foundation, Chicago, has also joined the same staff.

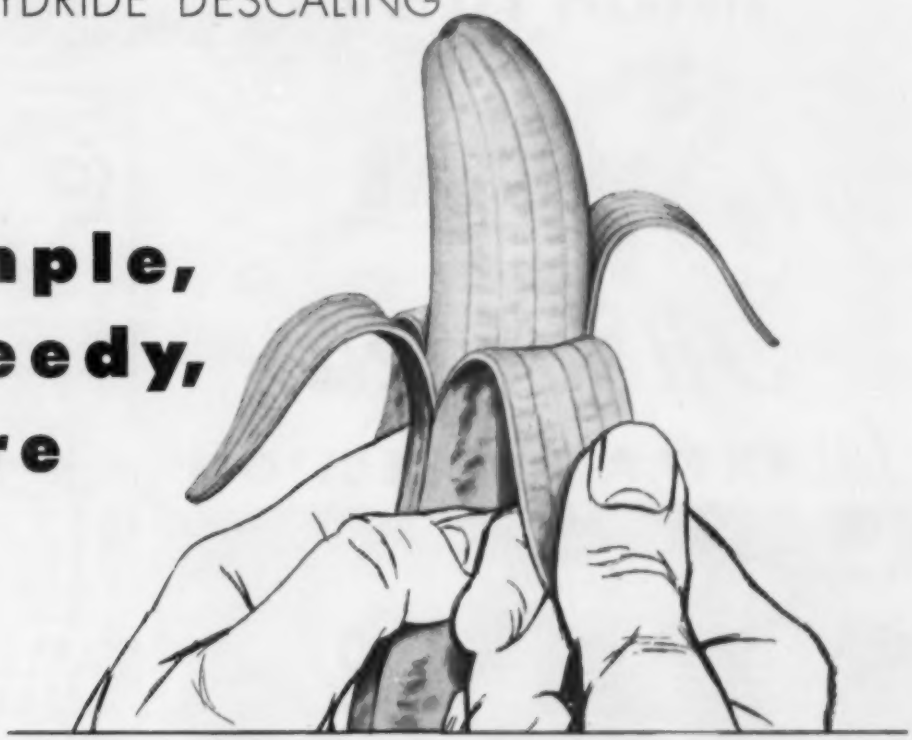
William H. Rice is a recent addition to the technical staff at Electric Steel Foundry Co., Portland, Ore. Dr. Rice served for 15 years as head of the welding department of Oklahoma Agricultural and Mechanical College. For the past two years he has been on leave of absence from Oklahoma A. & M. working for his doctorate at Oregon State College. In his new position he will serve as a consultant on problems relating to the welding of high alloys.

James B. Morey has been appointed in charge of the Cincinnati, Ohio, technical field section of the development and research division of the International Nickel Co., Inc., and **William S. Mounce** has joined the division's staff in New York City as a member of the constructional alloy steel section. Mr. Morey succeeds **C. T. Haller, Jr.**, who was recently appointed in charge of the company's Pittsburgh, Pa., technical field section. A graduate in mechanical engineering of Cornell University, Mr. Morey has been associated with International Nickel since 1939 when he joined the company as a member of the West Coast technical field section at Los Angeles, Calif. Mr. Mounce joined the company in 1945 as a member of the New England technical field section at Hartford, Conn. Graduating from Tufts College in 1939 with the degree of bachelor of science in chemistry, Mr. Mounce spent the next year at Massachusetts Institute of Technology as a special student in the metallurgical department. In 1940, he was appointed senior metallurgist with Hamilton Standard Propellers Div., United Aircraft Corp., East Hartford, Conn.

Richard W. Nelson is now project engineer for Winzen Research, Inc., St. Paul, Minn.

SODIUM HYDRIDE DESCALING

simple, speedy, sure



The sodium hydride process is being used more and more in the descaling and desanding of ferrous castings and forgings. And for good reasons. The process is fast —requires only minutes. Simple . . . needs only compact, carbon steel equipment. And economical . . . investment and labor costs are low. There's no acid waste disposal problem, no etching of parts.

Sodium hydride descaling removes scale formed in annealing, as well as sand encrusted or imbedded from the molding operation. Sodium hydride's uniform, penetrating action is low in cost, is more satisfactory than sand-or-shot blasting, particularly in deep holes or narrow crevices. Sodium hydride also removes residue from shell-molding operations cleanly and effectively.

For more information on how this simple, speedy, efficient process can lower your costs, increase your production, mail the coupon today.

ETHYL CORPORATION
Chemicals for industry

100 PARK AVENUE, NEW YORK 17, N.Y.

ATLANTA, BATON ROUGE, CHICAGO, DALLAS, DAYTON, DENVER, DETROIT, HOUSTON, KANSAS CITY, LOS ANGELES, NEW ORLEANS, PHILADELPHIA, PITTSBURGH, SALT LAKE CITY, SAN FRANCISCO, SEATTLE, TULSA, MEXICO CITY AND (ETHYL ANTIKNOCK, LTD.) TORONTO.

ETHYL SODIUM METALLIC ETHYL CORPORATION

ETHYL CORPORATION
100 Park Ave., New York 17, N.Y.

Please send me your brochure on Sodium Hydride descaling.

NAME _____

FIRM _____

ADDRESS _____

CITY _____ STATE _____

MP 2-55

AIRCRAFT PARTS AT

TEMCO

AIRCRAFT CORPORATION

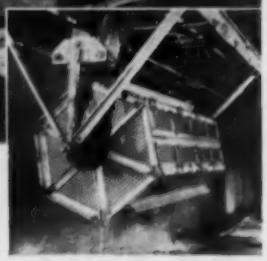
ARE

Alodized

WITH "ALODINE"®

for EXTRA PROTECTION

Man kneeling at left is adjusting faucet of "Alodine" tank. All tanks hold 5,500 gallons. Note simplicity of operation.



Small aluminum parts are Alodized in this power-driven squirrel cage tumbler.

Practically all painted aluminum aircraft parts at Temco are pre-treated with "Alodine."

If it's aluminum, be sure it's Alodized.

Alodizing improves paint-bonding and enhances aluminum's natural corrosion-resistance.

Alodized aluminum effectively meets the requirements of Military Specification MIL-C-5541.

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

DETROIT, MICH. NILES, CALIF. WINDSOR, ONT.

Personals . . .

Richard T. Myer has been appointed chief metallurgist of the aluminum fabrication division of Kaiser Aluminum & Chemical Corp., Oakland, Calif. Prior to joining Kaiser Aluminum Mr. Myer was chief metallurgist for three years at the Massena, N.Y., works of the Aluminum Co. of America, and previously spent 5½ years in the same position at that company's New Kensington, Pa., works. He is a graduate of Purdue University with a B.S. degree in chemical engineering and an M.S. in metallurgy.

Joseph E. Burke has been named manager of the newly created ceramics studies section in the metallurgy department of the General Electric Research Laboratory, Schenectady, N.Y. Dr. Burke is a graduate of McMaster University in Hamilton, Ont., receiving his Ph.D. from Cornell University. During World War II he was on the staff of the atomic weapons laboratory at Los Alamos, N.M., and from 1946 to 1949 taught at the University of Chicago. From 1949 until early in 1954, Dr. Burke was manager of metallurgy at Knolls Atomic Power Laboratory, joining the research laboratory staff in February. He is the author of a wide variety of metallurgical publications.

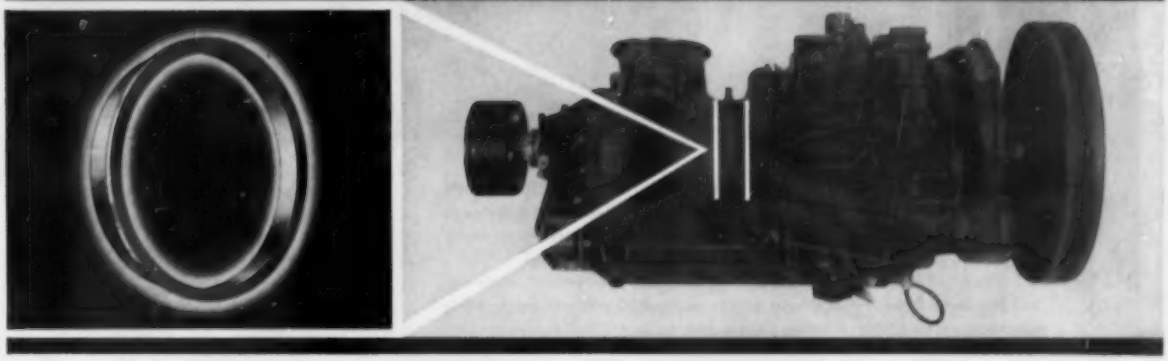
Richard A. Endsley, formerly with P. R. Mallory & Co. as physical metallurgist, is now project engineer, aircraft engineering department, Surface Combustion Corp., Columbus, Ohio.

Joseph H. Bach has joined the Westinghouse Atomic Power Division in Pittsburgh as assistant to manager of the fuel element subdivision. Until recently he was section head of the atomic energy division of Sylvania Electric Products. He has been active in the nuclear energy field since early 1948 when he joined the Hanford Works of General Electric Co. at Richland, Wash., as a metallurgical engineer.

R. Maddin, visiting lecturer in metallurgy at the University of Birmingham, England, for 1954, has returned to his post as associate professor at the Johns Hopkins University.

BOEING chose LEBANON

...to make the STAINLESS STEEL CASTING for the powerplant of a JET TRUCK



The Lebanon Circle (L) Casting in the Boeing 502 Gas Turbine is a product of the Centri-Die process. The complete story of this and other Lebanon Centrifugal Castings is told in a 12-page brochure. Copies are available by writing to William H. Worrilow, Jr., General Sales Manager, Lebanon Steel Foundry, 119 Lehman Street, Lebanon, Pa.

ON the highways of the Far West a 25-ton trailer truck has been powered more than 60,000 miles by a midget engine weighing only 240 pounds!

Midget in size but mighty in power, this revolutionary new power plant is the BOEING 502 Gas Turbine, developed by Boeing Airplane Company as a test model that has wide significance for the entire field of vehicular propulsion.

At the heart of the Boeing 502 is heat—searing, power-packed heat of over 1500°. Surrounding, containing and resisting this inferno is a stainless steel casting especially selected for the job—a LEBANON Circle (L) Casting, made at Lebanon Steel Foundry by people who, with Boeing, are looking toward the future.

CIRCLE L (R)

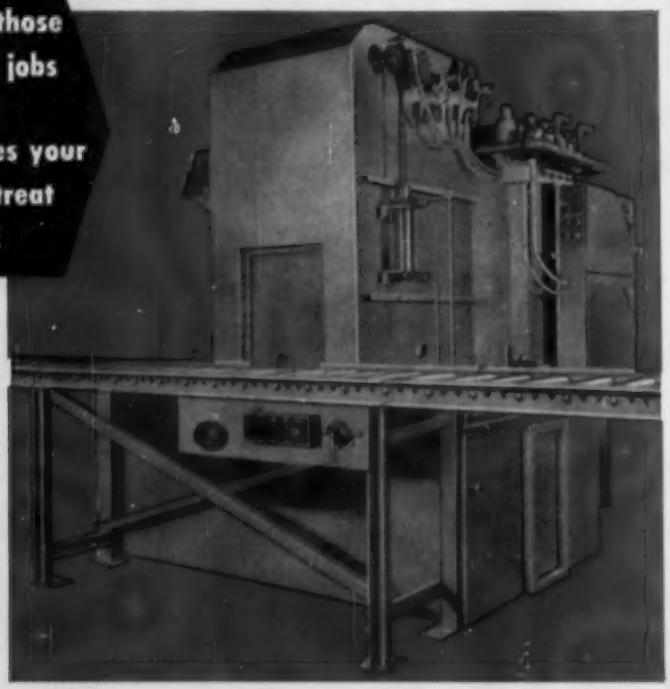
LEBANON STEEL FOUNDRY

LEBANON, PENNA.

Carbon, Low Alloy and Stainless Steel Castings

DOW'S "J-800" MODEL

Licks those tough jobs
•
Slashes your heat treat costs!



"NO-GAP" OPERATION—A batch type furnace with less than 30 seconds between loads. Work chamber is never exposed to air. Loading is accomplished while slow cooling or quenching a previous load.

GREATER PRODUCTION—Actual field operation has proven conclusively that the Dow Model J-800 will easily bring 800 pounds from room temperature to 1500° F in less than one hour.

COMPACT CONSTRUCTION—Occupies floor area of only 7'10" x 14'4" giving maximum production for minimum floor space.

VERSATILITY—Ideal for carbonitriding, gas carburizing, clean hardening and carbon restoration. Hot oil quenching and atmosphere cooling equipment available.

EXCLUSIVE FEATURES—High capacity fan combined with heat capacitor assures uniform case depth throughout each load • Forced circulation of quench oil assures uniform hardness with minimum distortion • Sealed quench tank gives cleaner stock—minimizes fire hazard.

DOW FURNACE COMPANY

Quality is your best investment

12045 Woodbine Ave., Detroit 28, Mich.
Phone: KEnwood 2-9100

Personals . . .

Wade H. Shafer, captain in the U.S. Army Ordnance Corps, has been transferred from duty in Mission to Turkey to the Aberdeen Proving Ground, Md. Captain Shafer has been assigned to the Human Engineering Laboratory.

Arlen S. Kjelby is now a lieutenant, junior grade, in the U.S. Navy and stationed in the U.S. Navy office in Cleveland as engineering design officer.

Louis M. Gamache is presently located in Schenectady, N.Y., and assigned to the large steam turbine and generator division of General Electric Co. He completed 12 weeks training at the Bridgeport, Conn., works in the fan division prior to this assignment.

Daniel B. Kulp resigned his position as metallurgist with the Alcoa, Tenn., works of Aluminum Co. of America to become metallurgist in the technical department, Madison Div., Dow Chemical Co.

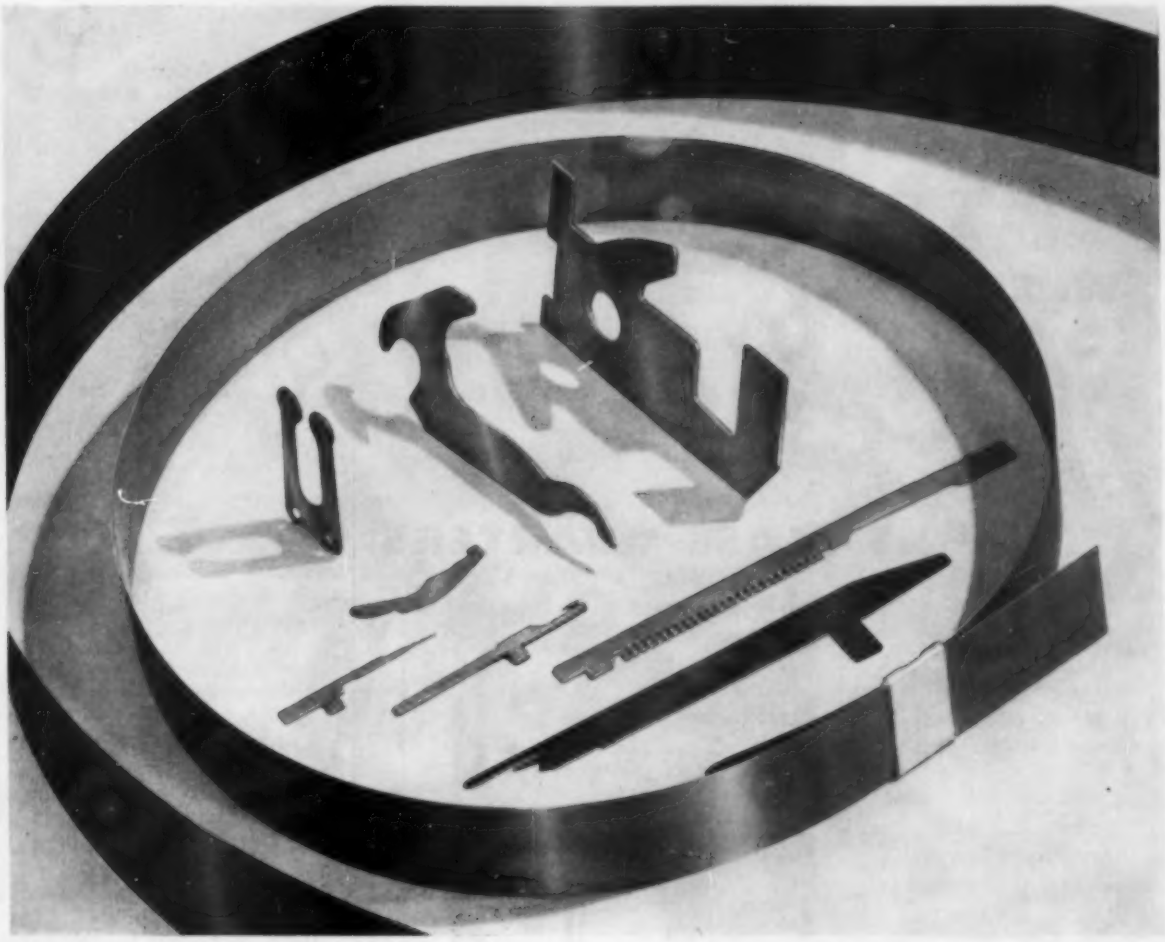
Joseph J. Tompos has enrolled in the Ohio State University graduate school to continue further metallurgical studies after spending the last nine years with the quality surveys division of the United States Steel Corp. at Pittsburgh.

T. W. Ambrose, formerly engineering assistant at the Hanford Works of General Electric Co., Richland, Wash., is registered in the graduate school at Oregon State College where he is majoring in chemical engineering.

William H. C. Webster has been transferred from the New York district sales office of Weirton Steel Co. to the Rochester, N.Y., district office and has been appointed district sales manager.

Robert F. Harvey has accepted a position as sales engineer with Parker Rust Proof Co., Detroit. He was previously research project engineer for Bohn Aluminum and Brass Corp. in the same city.

William C. Erdman is now an engineer in the products department of Allison Div. of General Motors Corp. in Indianapolis, Ind.



TOUGH JOBS NEED TOUGH STEELS

These precision parts, made for textile knitting machines and refrigerator valves, take a terrific beating. That's why the manufacturers' requirements are so high. Strength, precision, and flatness are musts. And that's why Uddeholm Swedish cold-rolled strip was used to make them.

Furthermore, on large scale stamping runs, like those for making the parts above, it is very important that the strip be uniform in chemical composition, physical properties, flatness, thickness, and finish. And that's another reason Uddeholm filled the bill.

If you want uniformly high grade, cold-rolled strip—wide or narrow, thick or thin, hardened or annealed, finished blue or straw or bright—just let us know.

Stocks of clock spring steel, bandsaw, flapper valve, thickness gauge, razor, and many other types, are carried in New York, Cleveland, and Los Angeles.

WRITE FOR SUBSCRIPTION TO UDDEHOLM'S MONTHLY STOCK LIST OF STRIP STEELS.

UDDEHOLM, 155 East 44th St., New York 17, N. Y.

Please send me monthly strip steels stock list.

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

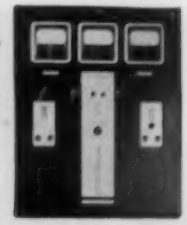
UHB

UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels
Specialty Strip Steels

New York: 155 East 44th Street, MUrray Hill 7-4575
Cleveland: 3756 Carnegie Avenue, HEnderson 1-7440
Los Angeles: 5037 Telegraph Road, ANgelus 2-5121

The Westinghouse 250 kv control ▶



250 kv constant potential transformers ▼

WHEN IT'S

Tough

AT CLOSE QUARTERS

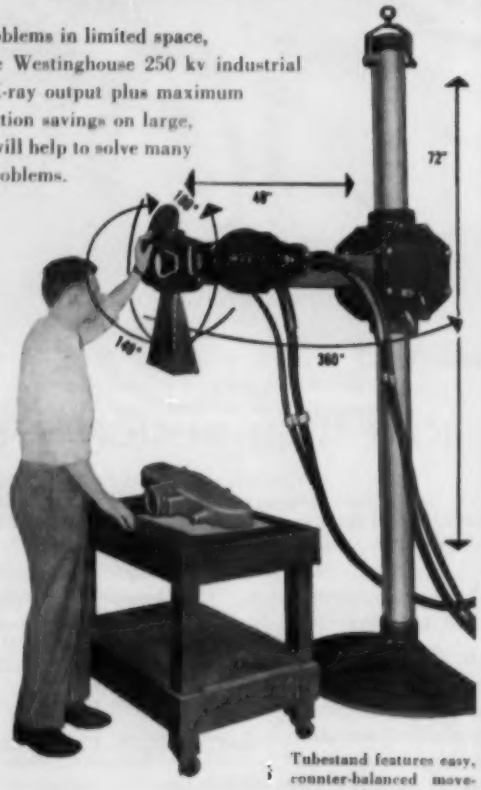
For heavy-duty inspection problems in limited space, nothing beats the dependable Westinghouse 250 kv industrial tubestand X-ray unit. High X-ray output plus maximum maneuverability means inspection savings on large, cumbersome parts. This unit will help to solve many of your toughest inspection problems.

Examine the 250 kv unit—note these outstanding features which guarantee high quality radiographs:

- Ease of operation
- X-Actron milliamperage control
- Constant potential for highest X-ray output
- Direct kilovoltage reading
- Load pre-set
- Fine focal spot X-ray tube

Call your Westinghouse representative, or write: Westinghouse Electric Corp., 2519 Wilkens Avenue, Baltimore 3, Maryland.

J-73308



Tubestand features easy, counter-balanced movements with positive locks

YOU CAN BE SURE...IF IT'S

Westinghouse

INDUSTRIAL X-RAY

Personals . . .

John E. Fahlman has been appointed to the newly created office of executive vice-president of the Permold Co., Medina, Ohio. A graduate of the University of Michigan with a degree of bachelor of science in metallurgical engineering, Mr. Fahlman has been general manager and assistant secretary of the company since 1953. He retains the office of assistant secretary in his new capacity.

Arthur L. Geary recently joined the staff of Electro Metallurgical Co., a division of Union Carbide and Carbon Corp., Niagara Falls, N.Y., as a senior research assistant with the metals research group. He was previously a project supervisor in charge of corrosion research for Weirton Steel Co., Weirton, W.Va.

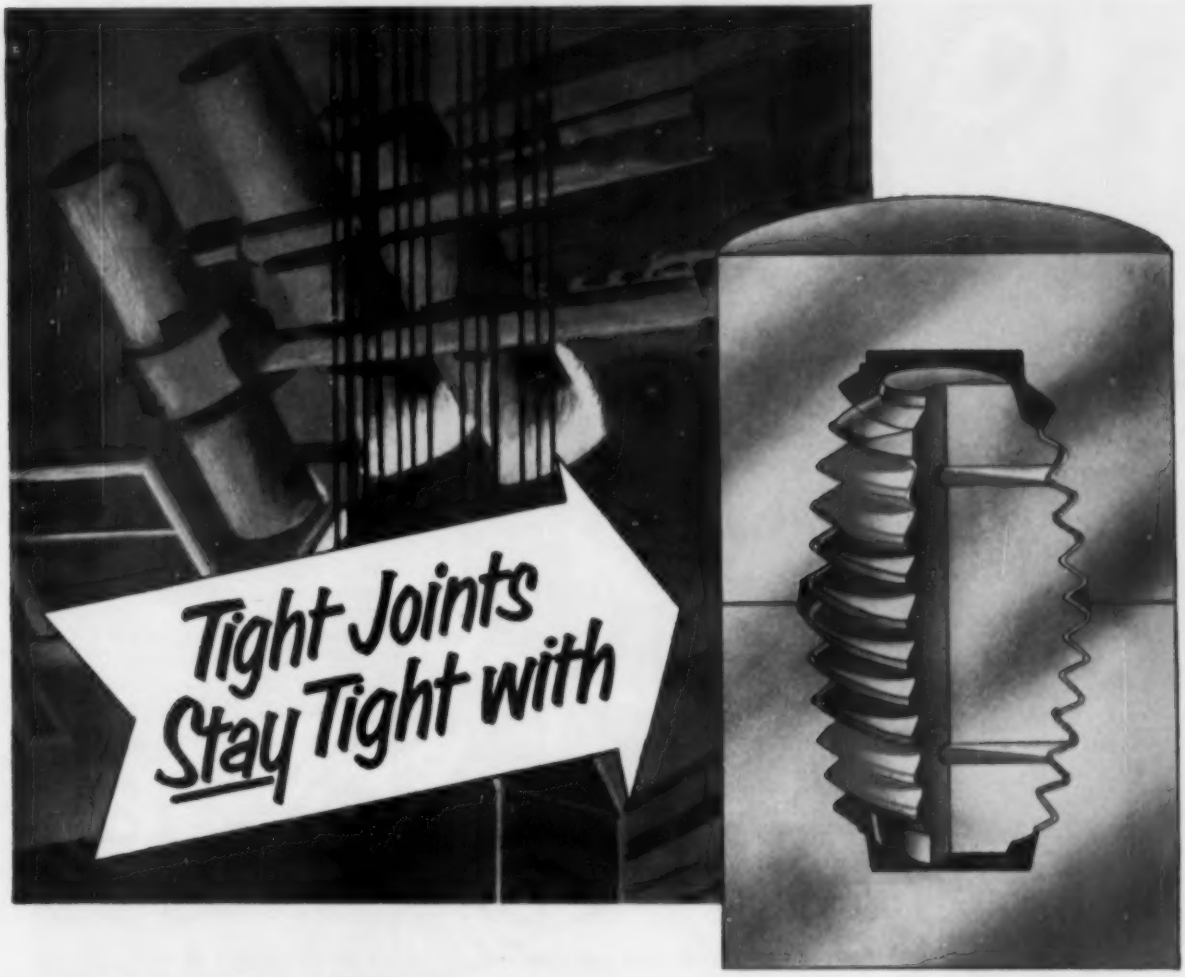
Bernard Gross, former director of laboratories of Rohr Aircraft Corp., Chula Vista, Calif., is now president of Chem-tronics, Inc., San Diego, Calif. Mr. Gross is a graduate of the Polytechnic Institute of Brooklyn, and has written many technical articles on aircraft materials and processes and has been granted numerous patents.

Harry R. Salmon, formerly a foreman with the Canadian Acme Screw and Gear Co., Toronto, is now technical representative of the metals division of H. L. Blachford, Ltd., Montreal.

Leroy W. Davis has been appointed technical superintendent at the aluminum forging plant recently acquired by Kaiser Aluminum & Chemical Corp., Erie, Pa. Mr. Davis had been technical superintendent of the Kaiser Aluminum plant at Halethorpe, Md., and prior to that had many years of experience in the aluminum forging and casting industries.

John R. Stewart, Jr. is now a metallurgist on the Dunkirk, N.Y., plant staff of Allegheny Ludlum Steel Corp.

W. J. Bratina, who received the degree of Ph.D. from the University of Toronto, is now employed as research fellow in solid state physics at the Ontario Research Foundation, Toronto.



NATIONAL PITCH-RESERVOIR NIPPLES*

TRADE-MARK

THE NEW PITCH-RESERVOIR NIPPLE, an exclusive "National" product, is another major contribution by National Carbon Company to more efficient electric furnace operation. You can now be sure that tight joints will stay tight under normal load and service conditions.

"NATIONAL" PITCH-RESERVOIR NIPPLES, designated Type PR-F, are now available for electrode diameters from 14" to 24". Thoroughly proved in service, they are identical in strength, size, shape, tolerances, composition and quality to our standard, tapered, graphite nipples. Talk it over soon with your National Carbon Company electrode representative.

***PATENTS PENDING**
EXCLUSIVE DESIGN

HERE'S HOW IT WORKS:

Reservoirs near each end of the nipple contain pitch. As the electrode column becomes hot in service, the pitch flows from the reservoirs into the threaded sections of the joint and cokes out, cementing and locking the threads of the nipple and sockets together.

FOR ELECTRODES AND ELECTRODE SERVICE...
Rely on NATIONAL CARBON COMPANY!

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto

"HANDS" THAT HELP MOVE THE EARTH!

. . . those unseen hands that put action into the earth moving giants . . . the hundreds of shapes and sizes of steel castings that make up excavating and mining machinery. Hands that are unnoticed and are subject to shock, stress and abrasion . . . all examples of Unitcasting's dependability.

Gears, cams, rockers, sheaves, stanchions, levers, protective housings, and many other parts made to exacting standards . . . subject to rigid inspections. Foundry engineered Unitcastings are the answer when the going gets rough!

Assured dependability in parts? Specify Unitcastings! Unitcast's representative is as convenient as your telephone. Call today!

UNITCAST CORPORATION • Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

QUALITY STEEL CASTINGS

Personals . . .

George E. Stein received his master's degree in metallurgical engineering in June 1954 from Purdue University where he had been a part-time instructor in metallurgy, and is now employed as metallurgist with Reynolds Metals Co. in the metallurgical research laboratory at Richmond, Va.

Alfred Francis is now chief metallurgist at Supreme Products, Inc., Chicago.

Robert W. Bennett has been promoted from chief metallurgical engineer at the Alco Products Div., American Locomotive Co., Dunkirk, N.Y., to chief metallurgical engineer of the newly organized general engineering and testing department.

George J. Thompson, formerly with Universal-Cyclops Steel Corp., Titusville, Pa., is now a metallurgist with Thompson Products, Inc., Cleveland.

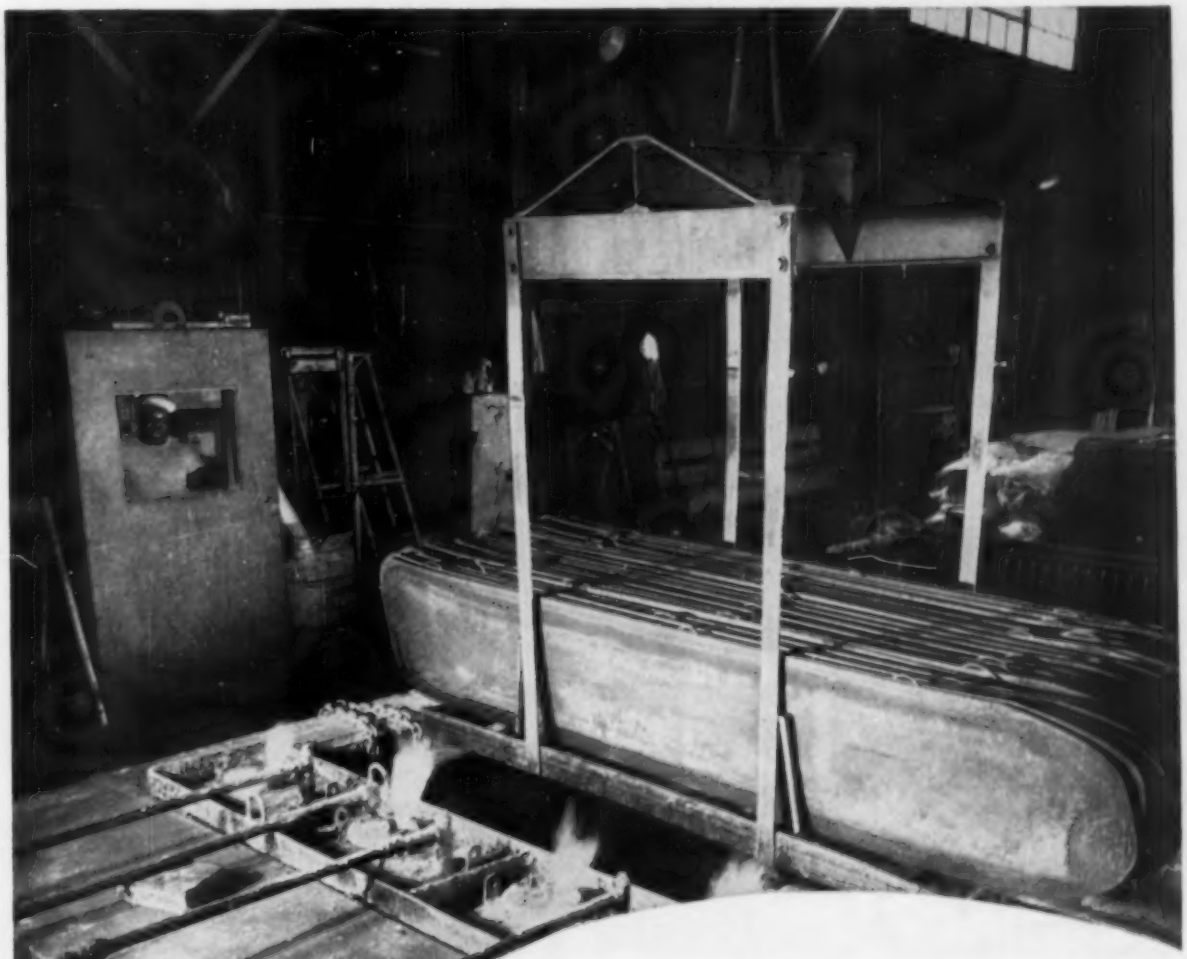
Willard L. Hults, successively plant manager, vice-president of factory operations, and executive vice-president of Schnefel Bros. Corp., Newark, N.J., was recently elected president of the corporation.

John C. Bullen is now project engineer in the research division of the Kent-Moore Organization, Inc., Detroit.

R. R. Williams, Jr. has been appointed manager of mines for the Colorado Fuel and Iron Corp. A graduate metallurgical engineer from the Colorado School of Mines, Mr. Williams began work for C.F. & I. in 1925, and has been employed in various departments in the Pueblo, Colo., steel plant. He had served as superintendent until December 1953, when he was promoted to assistant manager of mines, the position he held at the time of his new appointment.

Leroy K. Crockett, a June '54 graduate of University of Utah, is now a metallurgist with Aluminum Co. of America, Vernon, Calif.

G. H. Sengelaub has been transferred to the Permanente Foil Plant of Kaiser Aluminum & Chemical Corp. and is now plant metallurgist.



Safely descale most metals in 20 minutes or less!

WITH THE DU PONT SODIUM HYDRIDE PROCESS

You can thoroughly descale any metal unaffected by fused caustic at 700°F.—in any size or shape—within 20 minutes in a sodium hydride bath. And because bath action stops the instant scale is reduced, there's no loss of valuable base metal—no pitting or etching to cause costly rejects.

Du Pont—pioneer of sodium hydride descaling—will be glad to give you all the details about its economical, easy-to-operate process. Just write or phone Du Pont's nearest district office or mail the coupon below.

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Electrochemicals Department, MP-2
Wilmington 98, Delaware

☐ Send me your descriptive booklet on Sodium Hydride Descaling.

☐ Have a Du Pont man call. I am descaling _____

Name _____

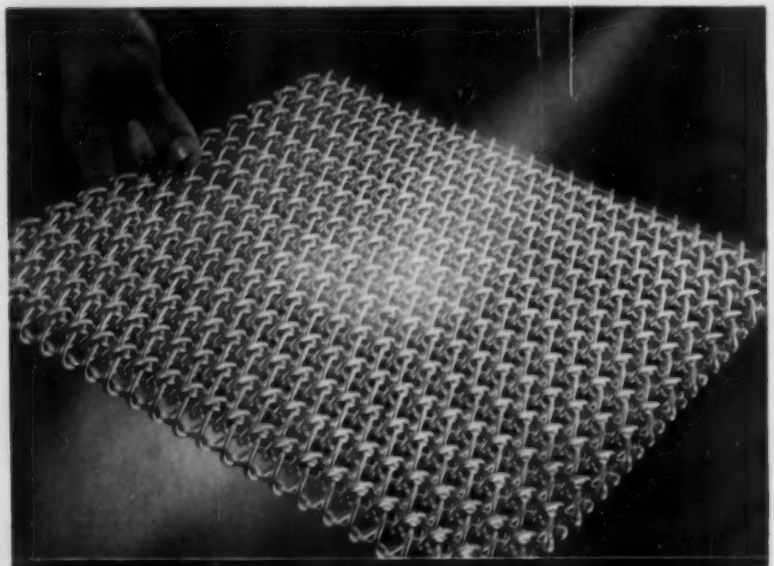
Position _____

Firm _____

Address _____

City _____

State _____



FREE CIRCULATION!

means continuous low-cost heat treating

with *Cambridge*

WOVEN WIRE CONVEYOR BELTS

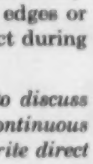
Open mesh construction lets heat and gases circulate freely all around the work for uniform annealing, brazing, sintering at controlled rates of speed. Moving belt eliminates batch handling, cuts costs, provides continuous production.

All-metal Cambridge Woven Wire Conveyor Belts are impervious to damage from constant operation at temperatures up to 2100° F . . . have no seams, lacers or fasteners to wear more rapidly than the body of the belt, no localized weakening. Open mesh also permits free drainage of process solutions in quenching, pickling and tempering.

No matter how you look at it, CAMBRIDGE Woven Wire Conveyor Belts are invaluable aids to AUTOMATION . . . eliminate profit-stealing batch and hand operations. They are made in any size, mesh or weave, and from any metal or alloy. Special raised edges or cross-mounted flights to hold your product during movement are available.

Call in your Cambridge Field Engineer to discuss how you can cut heat treating costs by continuous operation. You can rely on his advice. Write direct or look under "BELTING, Mechanical" in your classified telephone book.

WRITE TODAY FOR FREE 130-PAGE REFERENCE MANUAL illustrating and describing woven wire conveyor belts. Gives mesh specifications, design information and metallurgical data.



ANNEALING BRASS PARTS Process atmosphere circulates freely through open mesh of Cambridge belt and around small or large parts.

The Cambridge Wire Cloth Company

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department B
Cambridge 2, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

A Forgeable High-Temperature Chromium-Iron Alloy*

A PROGRAM was undertaken by the Battelle Memorial Institute to devise a forgeable high-strength, high-temperature alloy in the chromium-rich end of the chromium-iron system that would be suitable for turbine buckets in turbojet engines. Because the best alloys now available for such applications employ nickel and cobalt, the demands of a large-scale military program would exceed the supply of these elements. Chromium, which is relatively more abundant, is of great potential interest; although chromium has poor ductility, carefully prepared chromium-iron alloys may be ductile.

The objective was to produce a forgeable alloy with 60% or more chromium, at least 25% iron, and not more than 2% of the more strategic elements such as columbium. The requirements were:

1. The alloy must be sufficiently ductile at room temperature to be readily worked.

2. The alloy must have a minimum tensile strength at room temperature of 120,000 psi.

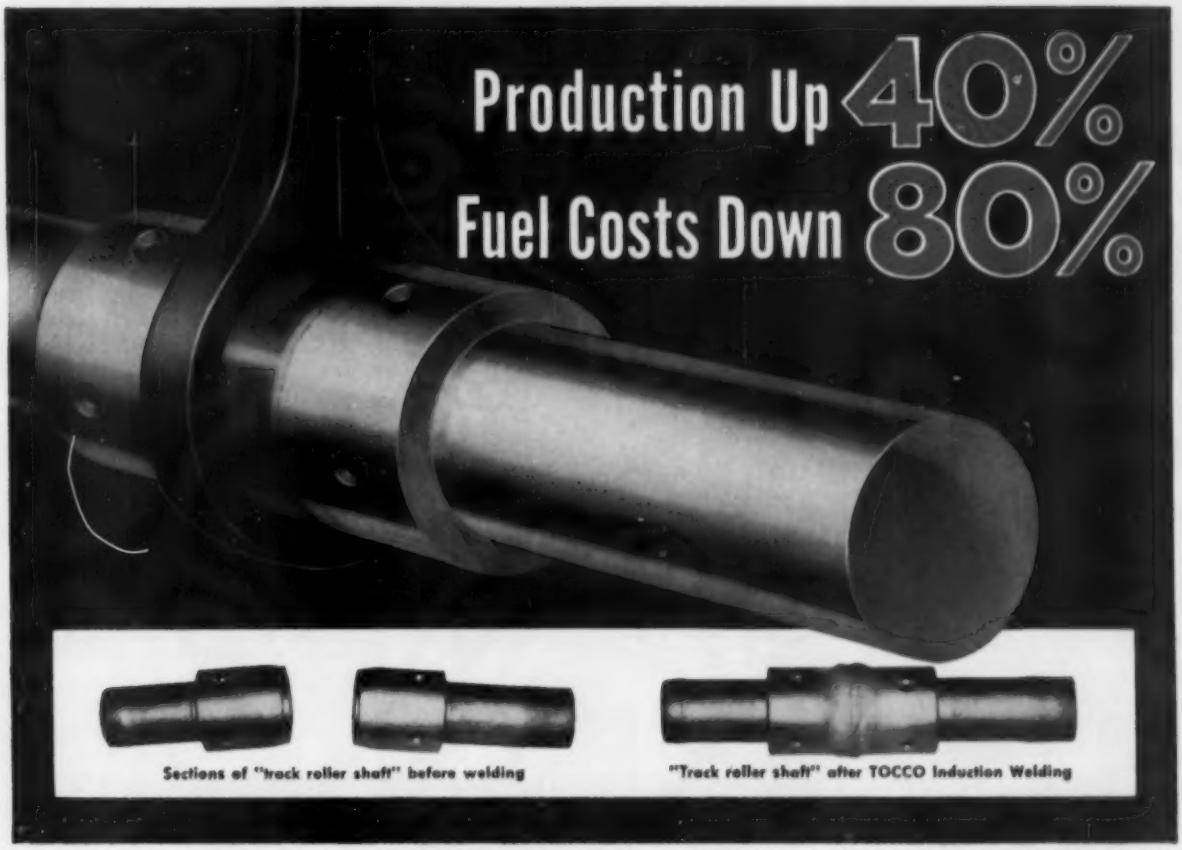
3. It should have the following minimum creep properties: *(a)* at 1350° F. – 1% deformation in 500 hr. at 25,000 psi.; *(b)* at 1500° F. – 1% deformation in 500 hr. at 17,500 psi.; *(c)* at 1600° F. – 1% deformation in 100 hr. at 12,000 psi.

4. The minimum rupture properties should be: *(a)* at 1350° F. – 500 hr. to rupture at 32,000 psi.; *(b)* at 1500° F. – 500 hr. to rupture at 19,000 psi.; *(c)* at 1600° F. – 500 hr. to rupture at 11,000 psi.

Fused chromium and Armco iron were used for the melting stock. These were charged into a magnesium-lined high-frequency induction furnace. Melting was under a lime-aluminum slag and an argon blanket (use of the argon was later discontinued). Additions of electrolytic manganese, calcium-silicon, and

(Continued on p. 140)

*Digest of "The Development of a Forgeable High-Strength, High-Temperature, Chromium-Rich, Chromium-Iron Alloy", by D. P. Moon, H. A. Blank and A. M. Hall (Battelle Memorial Institute), WADC Technical Report 53-451, January 1954.


Production Up 40%
Fuel Costs Down 80%
Sections of "track roller shaft" before welding
"Track roller shaft" after TOCCO Induction Welding

with TOCCO* Induction Welding

Here's the story of how one company, a large manufacturer of automotive equipment and farm implements, is using TOCCO Induction Heating to increase production and effect substantial savings at the same time.

Production Increased

When TOCCO Induction Heating replaced oxy-acetylene, output of these hollow "track roller shafts" went up from 220 to 300 pieces per 8 hour shift. The heating cycle with TOCCO is only 55 seconds as opposed to 90 seconds formerly required with gas. Result: much lower labor cost per unit.

Fuel Savings

Fuel costs nosedived from $10.50 per hundred pieces to only $1.95—about $25 per shift saved on fuel costs alone. Other important savings have resulted from a substantial reduction in down time and maintenance costs. Quality of the weld is more uniform with Induction, and hazards of explosion present with former method are eliminated.

If the manufacture of your product involves welding, heat treating, forging, brazing or the melting of ferrous or non-ferrous metals, don't overlook TOCCO as a sound method of increasing production, improving product quality and slashing costs.

THE OHIO CRANKSHAFT COMPANY

TOCCO

Mail Coupon Today

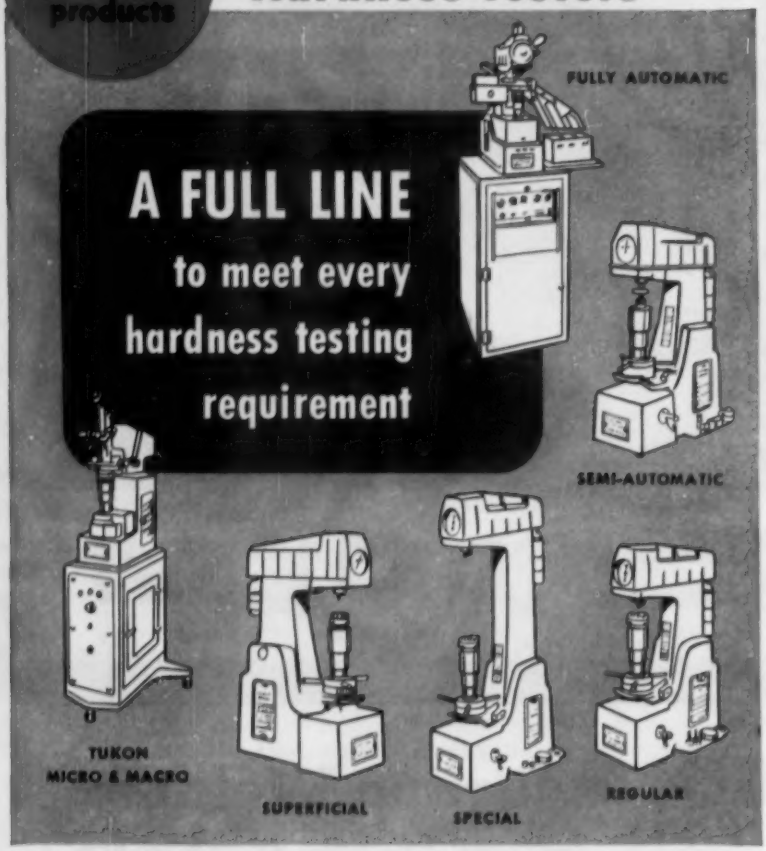
FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. R-2, Cleveland 1, Ohio
Please send copy of "TOCCO Induction Heating."

Name_____
Position_____
Company_____
Address_____
City_____ Zone____ State_____

ACCO products

Wilson "Rockwell"* Hardness Testers



• Hardness testing standards of the metal industry have been set and maintained by WILSON "Rockwell" Hardness Testers since 1921. In steel mills, non-ferrous mills and metal fabricating plants everywhere, WILSON "Rockwell" standards have been the mark of perfection for a generation.

What is your testing problem? Whether your material is hardened steel, sheet metal, small parts, tools, rounds, tubes, soft metals or plastic materials—all are tested quickly and accurately by one of the many WILSON models.

WILSON "Rockwell" precision has made them the standard by which all other hardness testers are compared. The WILSON full line makes it unnecessary to compromise with less than the tester most suited to *your* requirement.

Let a WILSON expert discuss your hardness testing problem. There is no obligation.

** Trade Mark Registered*

ACCO Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-F Park Avenue, New York 17, N. Y.

plus BRALES and TUKON

Cr-Fe Alloy . . .

nickel-magnesium were used as deoxidizing agents. Melts of 4 to 12 lb. were cast into rammed zirconite molds to produce ingots approximately 1¾ in. in cross section and 3 in. long.

Heating for forging was done by charging the ingots into a preheat furnace at 1600° F. and then heating to the forging temperature of about 2250° F. At first the thermal shock resulting from charging cold ingots into the hot furnace caused core cracking of the ingots. With slow heating to the forging temperature the ingots were successfully forged (to about ¾ in. square) without cracking. Some of the ingots were forged, flattened, and successfully rolled into 1/16-in. sheet at 1800° F. and to 0.050-in. sheet at 1200° F.

The original alloys of 70% chromium, 30% iron with additions of ½, 1, and 2 parts by weight of titanium, zirconium, vanadium and molybdenum alone and in combinations did not have the required high-temperature strength. Because of this, the subsequent alloys contained up to 17 parts by weight of alloy additions such as titanium, zirconium, columbium, tantalum, carbon, nitrogen, boron, indium and thorium. Some could not be forged and others had poor stress-rupture properties at 1500° F. Adequate stress-rupture strength at 1500° F. was obtained in several alloys that contained, in parts by weight, 70 chromium, 30 iron, 9 molybdenum, 2 to 4 titanium and up to ½ aluminum. It was found that 2 parts of titanium improved the forgeability of the complex chromium-iron alloys, but that forgeability decreased with the higher molybdenum contents. Alloys with 12% molybdenum forged with difficulty, and alloys with 15% molybdenum crumbled during forging.

Stress-rupture tests at 1500° F. and 28,000 psi. showed that the 70 chromium, 30 iron, 9 molybdenum, 2 titanium and ½ aluminum alloy were well in excess of requirements. Room-temperature tensile tests were unsuccessful even though adequate testing precautions were taken. The specimens failed at a relatively low stress with negligible ductility.

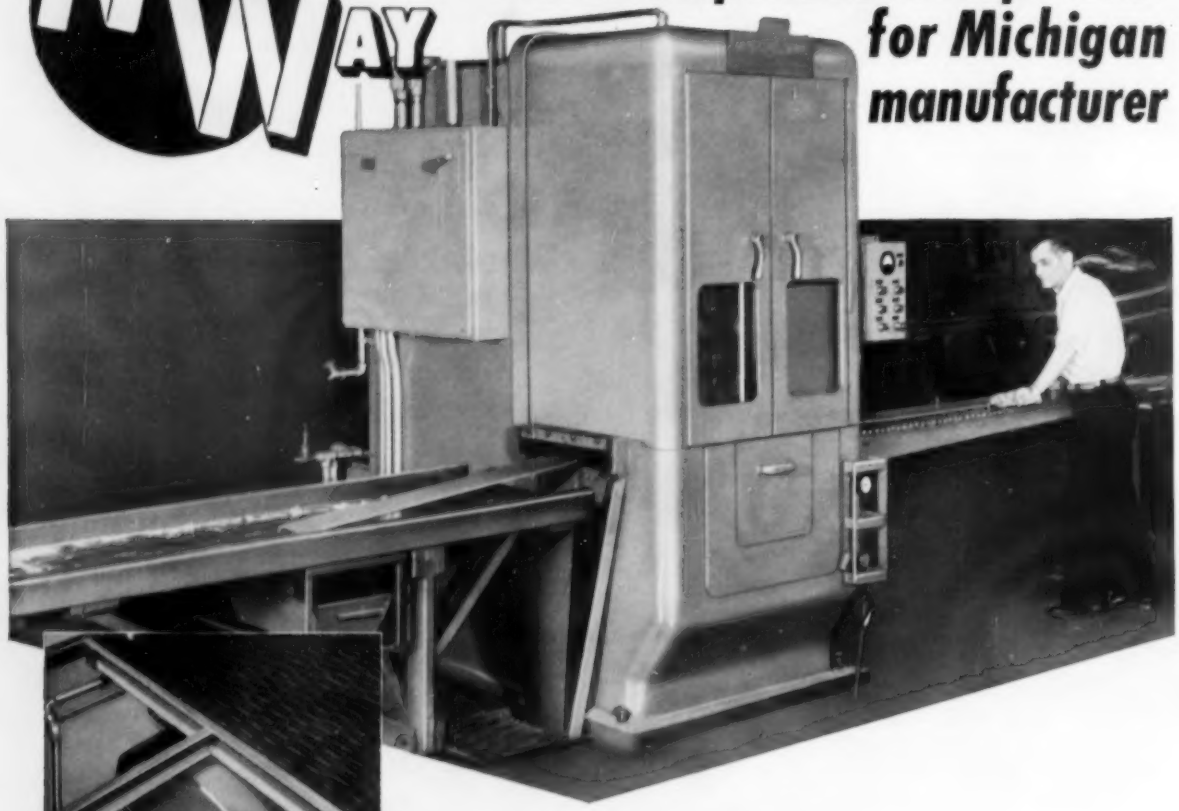
Several alloys were hot rolled at 1800° F. to 1/16 in. thick and then

(Continued on p. 142)

Bright as tomorrow!–Right for the years!
SUPERIOR
stainless strip steel
The sparkle that catches the car buyer's eye is a *permanent* pleasure with Superior Stainless. Time can't dull the brightwork made of this solid-bright metal. Superior Stainless Strip Steel is the dress-up feature that helps make the sale —and through superior performance, helps keep each owner sold. • Let us give you the facts on fabricating ease, gauges, tempers, finishes and coil widths for your needs.
Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

MURRAY WAY

MICRO-POLISH strip grinding boosts output over 600 percent for Michigan manufacturer



The New Murray-Way rotary filter which efficiently reclaims coolant on this operation. Permanent filtering media saves the cost of this equipment in a short time.

- ★ **Assures Product Uniformity**
- ★ **Cuts Material Loss and Scrap**
- ★ **Eliminates Down-time**
- ★ **Replaces Two Expensive Hand Operations**
- ★ **Facilitates Subsequent Operations**
- ★ **Improves Product Appearance**
- ★ **Eliminates Dust and Mess**
- ★ **Pays For Itself**

Here's one more illustration of Murray-Way's ability to do the job better, faster, and more economically.

Murray-Way's Automatic Equipment, thorough experience and expert engineering can save YOU money on YOUR polishing, buffing, grinding or filtering operations. Why not give us a call . . . JOrdan 4-6890 Detroit, or write for our complete, illustrated Micro-Polish Brochure.

MURRAY WAY

MURRAY-WAY CORPORATION

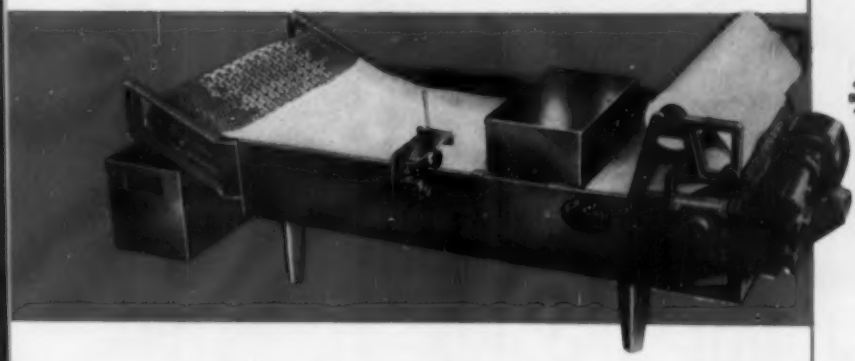
P. O. BOX 180, MAPLE ROAD EAST · BIRMINGHAM, MICH.

Polishing, Buffing, Grinding, Filtering Equipment that automatically cuts your costs.

Delpark FILTERS SAVE

NEARLY $4,000,000* ANNUALLY

On Grinding Operations



* Based on $1754.55 per filter savings shown in the 4-page brochure illustrated below

GET THE FACTS AND FIGURES ON THIS TERRIFIC SAVINGS STORY. WRITE FOR THIS 4-PAGE BULLETIN.

The savings made by DELPARK Filters in grinding operations is one of the outstanding developments in industrial cost reduction. DELPARK Filters are saving industry more money than any other production line liquid filter.

On grinding operations particularly, actual costs and savings pin point the importance of DELPARK coolant filtration in increased profits.

Today there are more than 3,000 DELPARK Filters in use in American industrial plants. Here is added proof of the wide acceptance, and recognized importance of DELPARK filtration in industry. If your applications are coolant, quench oil or any of the other industrial liquid filtration problems, DELPARK engineers can help you.

Backed by more than 40 years experience in industrial filtration problems.

Delpark INDUSTRIAL FILTRATION

INDUSTRIAL FILTRATION COMPANY, 116 INDUSTRIAL AVENUE, LEBANON, INDIANA

HERE ARE 2 REASONS WHY
you can count on
G. O. Carlson, Inc.
for
STAINLESS PLATE

the first is stock...

probably the largest stock of stainless plate in one location—produced to meet rigid chemical industry standards in a wide range of sizes, gauges and analyses.

the second is delivery...

the amount of diversified stock regularly carried at G. O. Carlson, Inc. assures fast delivery on all of the more active types and gauges.

and that's not all...

Special cutting equipment saves time and money where pattern cut stainless plate is required.

Highly skilled employees work on your orders—it's *right* when it comes from Carlson!

Complete-package orders—one order is sufficient for Carlson heads, rings, circles, flanges, forgings, bars and sheets (No. 1 Finish).

Why shop around...call Carlson first!

Stainless Steels Exclusively

G. O. CARLSON, INC.

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Cr-Fe Alloy . . .

warm rolled at 1200° F. to 0.050 in. This was an attempt to produce a fibrous grain structure which might give some ductility. The ductility was measured by means of bend tests using a V-block and a series of dies with radii ranging from 1⅛ in. down. All of the specimens broke in the largest die and the few that were annealed in air were somewhat more brittle. Specimens of 0.050-in. strip were annealed in an argon atmosphere to exclude nitrogen. Of these, the alloys of 55 chromium, 45 iron, 1 titanium, and of 60 chromium, 40 iron, and 1 titanium had a ductility equivalent to about 1% elongation. It is expected that the alloys containing molybdenum may have similar ductility following heat treatment.

Metallographic examination of the early chromium-iron alloys showed the presence of a grain-boundary phase, nitride inclusions, and a secondary phase which may have been a sigma phase. Although the grain-boundary phase did not affect forgeability, it probably contributed to the lack of ductility at room temperature. Annealing in air greatly increased the size and number of nitride inclusions. Electron-diffraction studies of the grain-boundary phase showed a structure characteristic of Ti(C, N, O) and a measured lattice constant that was close to the accepted value for TiN.

Conclusions

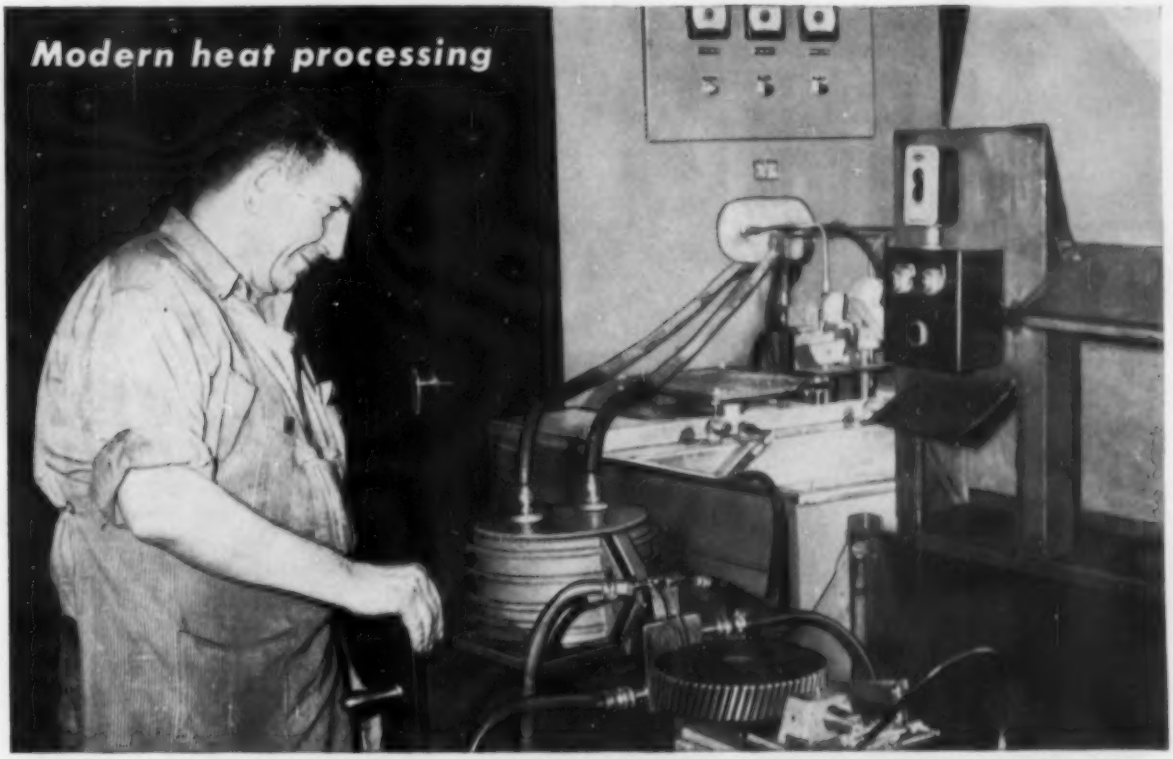
1. Forgeable chromium-iron alloys have been developed with excellent high-temperature properties. Best composition was 70 chromium, 30 iron, 9 molybdenum, 2 titanium, and ⅛ aluminum.

2. These alloys can be melted commercially.

3. Although this group of alloys exhibits poor ductility in the as-worked condition, work on less complex alloys indicates that room-temperature ductility can be obtained by heat treatment.

The ductility of the alloy of the best composition is not considered sufficient for the intended jet-engine application. Further experimental heat treatments may develop ductility in the more complex alloys similar to that of the chromium-iron alloys without molybdenum.

S. M. Jablonski



TOOTH-AT-A-TIME HARDENING USING G-E INDUCTION HEATER PRODUCES HIGH-QUALITY GEARS IN MANY SIZES.

Fifteen-inch gears quality hardened with 20-kw G-E induction heater

New Britain Machine eliminates grinding and copper plating costs

By switching from furnace to induction hardening with General Electric induction heaters, New Britain Machine Co., New Britain, Conn., improved their gears with a minimum investment in new equipment.

Equipment costs were reduced by installing a fixture that makes it possible to harden a tooth at a time. In this way, New Britain can heat-treat gears up to 15 inches in diameter with only a *20-kw* G-E heater.

Hardening is confined to the tooth surfaces, where the wear is greatest, leaving the core shock resistant. Formerly, New Britain either carburized and hardened the gears completely—a process which caused distortion and required expensive grinding—or they had to copper plate the gears for selective hardening.

For information on how you can cut costs and improve your products using G-E induction heat, contact your nearest G-E Apparatus Sales Office. And write for the new modern-heat processing bulletins—Forging with Induction Heat, GEA-5983, and Furnace and Induction Brazing, GEA-5889. Address: Section 720-137, General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC

WITH ACCURATE INDUCTION HEAT, hardening can be limited to areas where pressure and wear are greatest. Core remains shock resistant.

ROLOCK
FABRICATED HEAT AND CORROSION RESISTANT ALLOYS

FEATURES OF THE ROLOCK NEU-POT

WROUGHT ALLOY, strong, dense, uniform . . . gives thinner sections more rapid heat transfer, less hot spots, faster heat recovery.

●

ALLOY WELDS X-ray inspected . . . free from slag, air pockets, cracks. No premature failures due to these causes.

●

HEADS of fabricated pots stocked in standard diameter . . . wide range of depths quickly made without special patterns, tools.

HERE'S TERRIFIC SERVICE . . .

8000 Hours . . SO FAR . . with Neutral Salts!

Yes . . . that's really phenomenal cost saving . . . but Rolock customers expect and get more than normal use from our fabricated-welded heat treating equipment.

In this instance, it's a fabricated Inconel pot . . . ¼" plate . . . which withstands a 1550° F. operating temperature for 16 hours per day . . . stands idle for 8 hours . . . then over Sunday at about 1300° F. So far its life totals 18 months. This is probably a record, but many other Rolock neutral salt pots have served for 12, 14, 15 and 16 months . . . up to 5000 hours. Naturally, higher temperatures reduce service life.

If you require neutral salt pots of this type (any size), you will want specifications and quotations that will clearly show cost-cutting. Write for complete details of this up-to-the-minute equipment . . . or any other type of fabricated heat and corrosion resistant alloys.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST

ROLOCK INC., 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

IRLSS

Flame Versus Induction Hardening*

CASE HARDENING of low-carbon steel by heating in carbonaceous compounds is an art practiced for over a century. Similarly, production of a thinner hard surface by dipping in molten cyanide has been commercial for many decades. Use of oxy-acetylene or oxy-gas flame for hardening the surface layer of more massive pieces of medium-carbon steel is of fairly recent date and competes with similar hardening done by induced high-frequency currents. The first induction hardening unit for commercial use was sold by Ohio Crankshaft Co. to International Harvester's Tractor Works in Chicago in 1935.

Conflicting claims have been made about the quality of surface hardening as performed by these methods, particularly about the thickness of the hardened case. Induction heating can give a hardness depth as shallow as 0.06 in. or even less. Ceramic-burner installations, at the other end of the scale, give a minimum case depth of 0.125 in. The hardness depth resulting from the use of the "Flamatic" oxy-acetylene hardening machine is intermediate.

To resolve differing claims, the American Gas Assoc. sponsored a research investigation at Battelle Memorial Institute. This study, as reported by S. L. Case and H. J. Grover, showed that:

1. No detectable distortion was caused by an increase in the thickness of the hardened case.

2. No differences in mechanical behavior between induction hardened and flame hardened specimens could be detected.

3. Very shallow hardened zones appeared to have no particular merit.

4. Grain size had no significant effect on the mechanical properties of the hardened layer. This was demonstrated by comparing the deeply hardened, course-grained surface zones of flame hardened specimens with the finer-grained, shallow hardness zones of induction hardened specimens.

5. In many instances, a more deeply hardened case than could be obtained readily by any of the three

(Continued on p. 146)

*Digest of "Selecting Surface Hardening Methods"; *Battelle Technical Review*, September 1954, p. 97.

Small Heat Production

is behind SANDVIK SPRING STEEL'S successful performance

Sandvik specialty steels are carefully produced in relatively small quantities which facilitate closer control and uniform results.

Pure Swedish ore and coniferous, sulphur-free fuel are used to produce pig iron of unusually high quality. Sandvik's small blast furnaces and steel furnaces afford closer control of the quality of each heat.

In the subsequent rolling and annealing operations, Sandvik applies its specialized experience, skill and equipment, — "tailoring" the steel to the precise gauge, hardness and surface finish required.

The final result is the inherent quality which has made Sandvik spring steel successful in so many exacting applications.

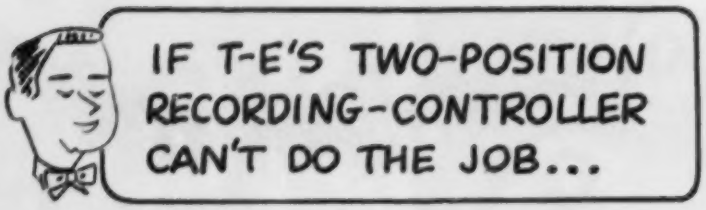
You can get Sandvik strip steels:

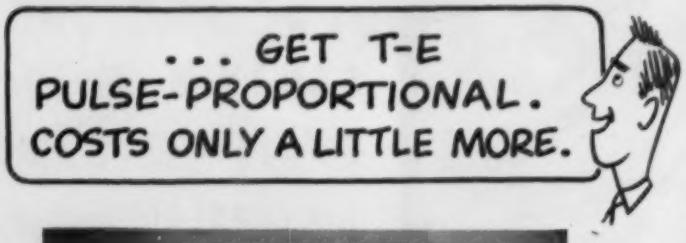
- **In special analyses for specific applications.**
- **Precision-rolled in thicknesses to fit your requirements.**
- **In straight carbon and alloy grades.**
- **Annealed, unannealed or hardened and tempered.**
- **Polished bright, yellow or blue.**
- **With square, round or dressed edges.**
- **Wide range of sizes in stock — also slitting facilities available.**

Ask your nearest Sandvik office for further information or technical assistance.

Sandvik Swedish Specialty Strip Steels are used for Textile Machine Parts such as sinkers, needles, etc. • Band Saws (metal, wood and butcher) • Camera Shutters • Clock and Watch Springs • Compressor Valves • Doctor Blades • Feeler Gauges • Knives such as cigarette knives, surgical, etc. • Razor Blades • Shock Absorbers • A Wide Variety of Springs • Trowels • Reeds: Vibrator, Textile, etc. • Piston Ring Segment and Expanders • and many other applications.

SANDVIK STEEL, INC.
111 EIGHTH AVE., N.Y. 11, N.Y. • WAtkins 9-7180
230 N. Michigan Ave., Chicago 1, Ill., FRanklin 2-5638
1736 Columbus Rd., Cleveland 13, Ohio, CHerry 1-2303
3609 E. Olympic Blvd., Los Angeles 23, Cal., ANgelus 3-4761
SANDVIK CANADIAN LTD., P.O. Drawer 430, Station O, Montreal 9, P.Q.
SANDSTEEL SPRING DIVISION • New York • Industrial Springs
SANDVIK SAW & TOOL DIVISION • New York • Saws and Tools





Thermo Electronic recording-controllers are relatively inexpensive instruments for recording and controlling temperature of electrically heated, fuel fired, or steam heated equipment. You can use them with two-position valves (electric or electric-pilot pneumatic types), contactors, or heavy duty relays. They will operate with thermocouples or resistance bulbs.

The pulse-proportional controller changes heat input according to the magnitude of temperature change. Its proportion band is continuously adjustable from 0% to 20% of range to match process response. Recommended for continuous and other processes having similar control characteristics, where load changes are relatively small, and where temperature changes cannot be detected quickly.

Two types of controller: potentiometer pyrometer and resistance thermometer. Both are durable, simple, accurate, sensitive, speedy, and easy-to-set. 23 scale ranges from −320° to +200°F all the way up to 0° to 3000°F. The 12" recording chart is easy-to-read.

Interested? Write for bulletin 62—H.

Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors
Thermocouple and Extension Wires • Resistance Bulbs • Connector Panels

Thermo Electric Co., Inc.

SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

Flame Vs. Induction . . .

methods was more desirable than the shallower case resulting from induction hardening.

Messrs. Case and Grover's conclusion was that, from the viewpoint of mechanical properties, there is no choice between the three surface hardening methods except in the case of thin-walled parts which can be surface hardened by induction only. The choice, therefore, can be based largely on such economic considerations as capital investment in equipment and labor and fuel costs.

Causes and Prevention of Weld-Metal Cracking*

Part I

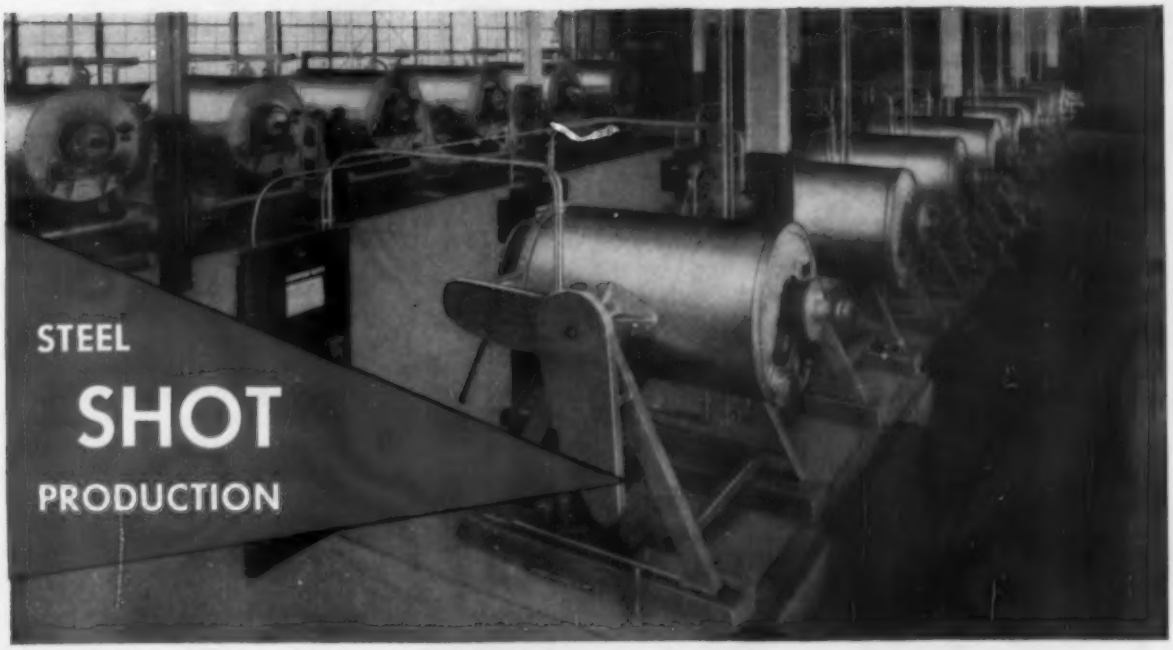
WELD-METAL cracking has plagued the welding engineer for a long time but during the past 15 years his problem was particularly acute with the introduction of the high-strength steels used in aircraft manufacture. Recognition of the problem led the Wright Air Development Center to authorize an investigation of the fundamental causes of weld-metal cracking and a means for its control. The initial phase of the investigation was a literature survey made by Battelle Memorial Institute. Of the 1450 published papers on this subject, a bibliography was compiled of about 850 references to the most pertinent papers.

Since there is considerably more information on the causes of low strength and embrittlement in non-welded metals than on the causes of weld-metal cracking, it was believed that the various factors affecting the ductility of these metals could be used to good advantage as a background in this study. Thus, the first part of the report was devoted to a review of the fundamental factors affecting the ductility of metals. The more important of these are briefly described as follows:

1. On cooling castings in the range of 2600 to about 2200° F., *hot tears*

(Continued on p. 148)

*The first of a two-part digest of "Literature Survey on Weld-Metal Cracking", by A. J. Williams, P. J. Rieppel and C. B. Voldrich of Battelle Memorial Institute, WADC Technical Report 52-143.



AGF No. 4 Rotary Carburizers and No. 71 Rotary Tempering Furnaces in the modern, efficient plant of the American Wheelabrator & Equipment Corp., Mishawaka, Indiana.

the only type of furnace that will UNIFORMLY HEAT TREAT large volume production of small work such as shot.

Heat treated steel shot as produced by the American Wheelabrator & Equipment Corp., Mishawaka, Indiana, is proven to outlast many times the previously equivalent kinds of shot, which were not heat treated. The only practical kind of furnace to do this kind of work is a rotary furnace such as illustrated.

Work handling is simplified and convenient. The constant rotation insures positive, uniform and rapid heating.

AGF factory trained engineers and metallurgists are available in principal industrial centers. Installations may be seen wherever industrial gas is available. For positive results and for practical economy call AGF PIONEERS.

Write for Bulletins No. 1212A and 805

AMERICAN GAS FURNACE CO.

1032 LAFAYETTE STREET — ELIZABETH 4, N. J.

WHY They "know their Steels" at Firth Sterling

MARSHALL TESTING FURNACES
"doing an excellent job"

METALLURGISTS everywhere are doing important work today and Marshall testing Furnaces are helping them. Take, for instance, Firth Sterling Inc., noted producers of special steels. They write:
"Your Marshall Tubular Furnaces are at work 24 hours a day in our Research Laboratory, either in stress-rupture testing of high-temperature Alloys, or in heating titanium alloy Cermets. They're doing an excellent job for us."
That's typical. Marshall Furnaces are used in atomic energy research; they're aiding jet engine makers to search among the borides, carbides and silicides for the right compounds; they're in use in automotive industry laboratories; in the manufacture of heavy machinery, etc.
Are you using Marshall Furnaces? They are available in standard types, or altered to suit your conditions, or built special. Holding brackets can be furnished in Stationary or Compensating types. Write for descriptive literature.

MARSHALL PRODUCTS CO.
270 W. Lane Ave., Columbus 2, Ohio

Marshall FURNACES -- CONTROL PANELS

Weld Cracking . . .

are formed in areas subjected to excessive strains due to uneven cooling or by restrictions to normal contraction. Hot tears are intergranular in nature and their formation is greatly influenced by the composition of the melt. Hot tensile tests of cast steel specimens made in rapid succession immediately after pouring showed that carbon steels were less susceptible to hot tearing than alloy steels.

2. Hot shortness, defined as *high-temperature brittleness*, is distinguished from the above-mentioned hot tearing by the inherent weakness of a reheated metal which makes it crack when worked at a high temperature. Most investigators believe that hot shortness in ferrous metals is caused by eutectic film at the grain boundaries. Metal compounds of sulphur and oxygen do form eutectic phase at the grain boundary and cause the intergranular weakness exhibited in the hot worked material. Sulphur appears to be the most common cause of hot shortness in steel above 2000° F., while oxygen seems to cause the hot shortness in steel when worked below 2000° F. Manganese appears to have the greatest influence in preventing hot shortness in ferritic steels.

3. Overheating steel above its normal forging temperature causes severe grain coarsening. Under conditions of extreme overheating, the steel is described as being "burnt". Burnt steel is brittle and may fracture during forging. The ductility of badly burnt steel cannot be restored by heat treatment.

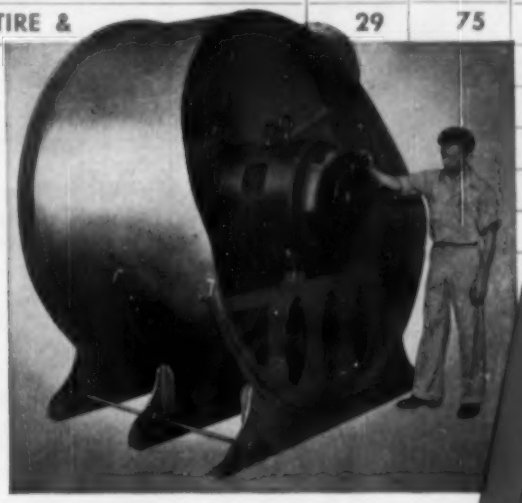
4. Blue brittleness occurs in some steels when worked in the temperature range of 300 to 1000° F. It is characterized by a reduction in ductility when tested in this temperature range. It is believed to be due to the precipitation of a grain-boundary constituent, probably nitride.

5. Temper brittleness is due to a precipitation process which may be related to blue brittleness, but with the difference that straining is not an influencing factor. Temper brittleness is manifested by a decrease in notch toughness when hardened steel is slowly cooled from some temperature below the transformation range, and tested at room temperature. The effects can be avoided by quenching

(Continued on p. 150)

	Jan. 1, 1940		Jan. 1, 1954	
	No. of Units	Total H.P.	No. of Units	Total H.P.
ALUMINUM CO. OF AMERICA	71	407	397	1962
AMERICAN CAN CO.	64	287	[illegible]	[illegible]
CHRYSLER CORP.	10	[illegible]	204	224
FORD MOTOR CO.	59	1152	[illegible]	4020
SUNSHINE BISCUIT CO.	19	76	78	652
WESTINGHOUSE ELECTRIC CORP.	65	377	206	3002
AMERICAN BRASS CO.	32	120	117	616
ALLEGHENY-LUDLUM STEEL CORP.	42	393	87	978
GOODYEAR TIRE &	29	75	66	159
			655	14421
			379	3261
			174	1324
			227	888
			260	2574
			154	761

Repeat Orders Tell the Story



SPENCER HARTFORD TURBOS

THE RECOGNIZED STANDARD FOR MORE THAN 30 YEARS

Spencer Turbos have been recommended by more than thirty oven and furnace manufacturers for more than a quarter of a century. In addition hundreds of large manufacturing companies have standardized on Spencer and placed repeat orders from year to year. (See above).

Simplicity, reliability and long life are the reason for this universal acceptance. If you wish to study the outstanding advantages of the Spencer Turbo and its many applications, ask for General Bulletin No. 126-A and the Turbo Data Book No. 107-D.

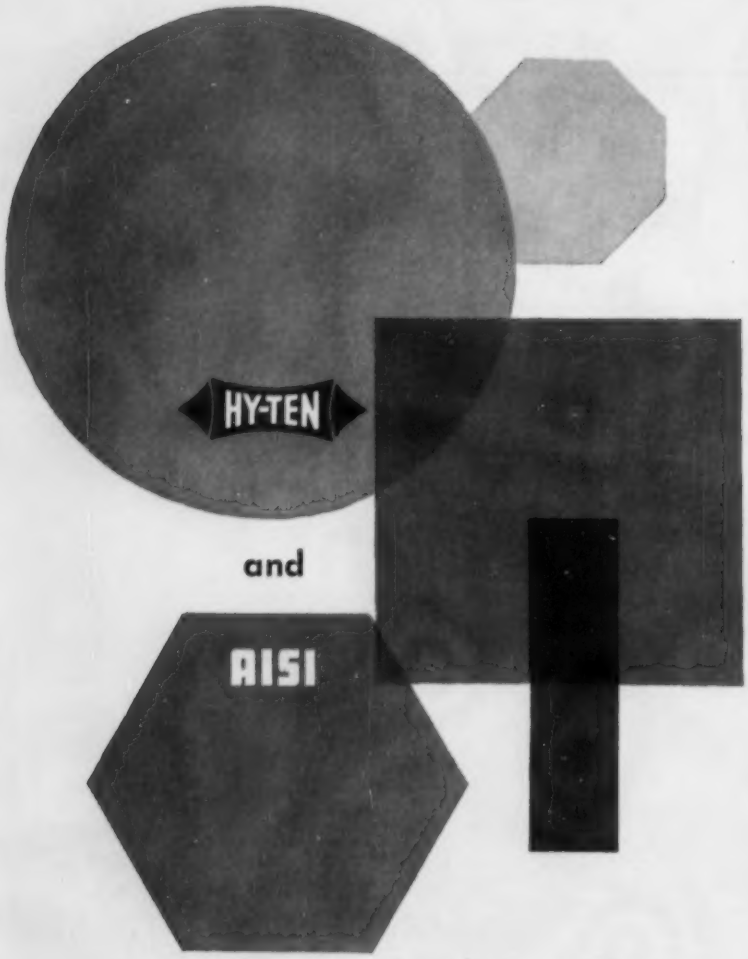
THE SPENCER TURBINE COMPANY

SPENCER HARTFORD

HARTFORD 6
CONNECTICUT

494-1

Manufacturers of Turbo-Compressors and Heavy Duty Vacuum Cleaners



bars, billets and forgings
in sizes, shapes and treatments for every need!

Wheelock, Lovejoy & Company, Inc., can fill your alloy steel requirements promptly. This applies to both standard AISI and SAE steels and to our own HY-TEN steels—"the standard steels of tomorrow". Take advantage of our seven strategically located warehouses. All of them can supply these steels in the form and quantity you need. Every warehouse, too, is staffed with expert metallurgists who are ready to serve you.

Write today for your FREE copies of Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

near you . . .

Warehouse Service—Cambridge • Cleveland • Chicago
Hillside, N. J. • Detroit • Buffalo • Cincinnati
In Canada—Sanderson-Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.
134 Sidney Street, Cambridge 39, Mass.

Weld Cracking . . .

from the tempering temperature.

6. Hydrogen embrittlement has long been a problem to users of steel. Hydrogen has an embrittling effect on steel because of its ability at high temperatures to permeate the metal as atomic hydrogen and collect in discontinuities such as blowholes, inclusions, cracks and submicroscopic rifts. On cooling, the metal becomes supersaturated with the hydrogen which then diffuses into the discontinuities. At lower temperatures the atomic hydrogen combines to form molecules of hydrogen which are too large to permeate the solid steel. As this reaction continues, the pressure of the hydrogen increases to such an extent that the metal can rupture. "Snowflakes", "fisheyes", "flakes", and "shatter cracks" are believed to be manifestations of hydrogen embrittlement.

All the factors affecting the strength and ductility of nonwelded metals listed above are related to the factors influencing weld-metal cracking. Weld-metal cracks can be classified by their microscopic or their visual appearance. Under the microscope they can be classified as being intergranular or transgranular. By visual inspection they can be classified as to the direction of cracking, notch cracking (as from a poor fit-up), fissuring or "fisheye" effects.

Weld-Metal Cracking

The two basic factors which influence weld-metal cracking are the formation of a highly stressed condition and the metallurgical properties of the weld metal. The accumulation of stresses in weld metal during fabrication is a function of joint design and temperature gradients. These originate primarily from the forces of expansion and contraction of the metal itself, and also through external or applied forces on the joint. Even though a weld metal shows an elongation of 15 to 40% in tensile specimens, this plastic flow is prevented in the solidifying and cooling weld metal because of constraint (triaxial stresses arising from shrinkage in all directions). When plastic flow is prevented, a brittle fracture occurs as soon as the cohesive strength of the metal is exceeded.

Welding authorities state that, if

(Continued on p. 152)

"Broaching 4140 Steel was giving them a tough time..."

A Michigan manufacturing company broaching 4140 Steel in a horizontal machine found their broach life unusually *low*. The machine shop superintendent tried a number of oils recommended by various companies, but found none satisfactory either for increasing tool life or producing the desired finish. On a routine call, Sinclair Industrial Representative M. L. Howland was asked for his recommendations.

Overheating was the villain...

Mr. Howland reports, "Overheating was the reason these tools were taking a beating. Examination showed the need for an oil with proper anti-weld, extreme pressure characteristics and correct viscosity. From previous experience, I recommended Sinclair ORDNANCE B, a heavy duty cutting oil."

Broach life doubled...

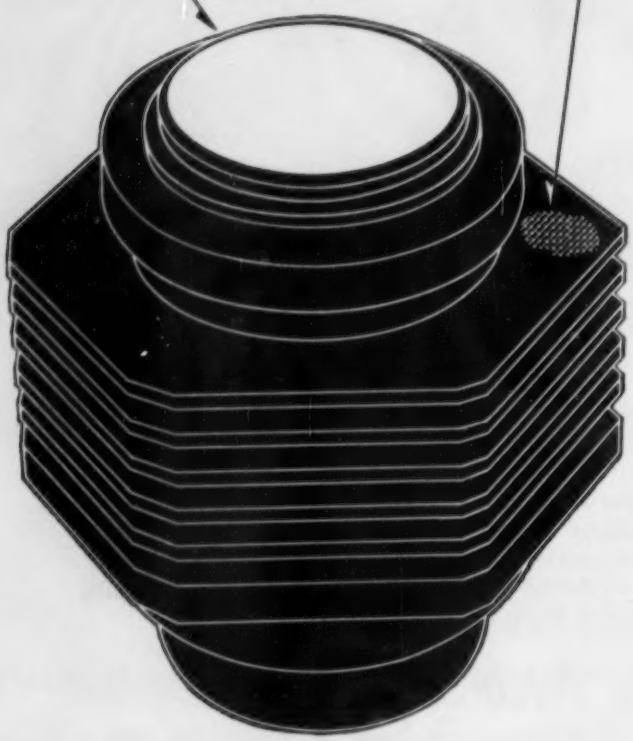
Mr. Howland continues, "Following my recommendations, the superintendent tried Sinclair ORDNANCE B on a test basis. On a follow-up, I learned that the broach life had been *doubled* and the finished pieces were free from tool marks. The company now specifies Sinclair ORDNANCE B *100% for its broaching operations.*"

Why not let a Sinclair Lubrication Engineer help solve *your* lubrication problem. *There's no obligation.* Contact your local Sinclair office or write Sinclair Refining Company, 600 Fifth Avenue, New York 20, N.Y.

SINCLAIR LUBRICANTS

Chromium

ON ALUMINUM..



Something *New* in pneumatics

by VAN DER HORST

Write for additional information on this specialized application for Chromium.

Dept. M-I, VAN DER HORST CORP., OLEAN, N. Y.

Weld Cracking . . .

welded joints were perfectly designed to handle the stress, there would be no concern about the other factors. The difficulty in design for welding is that each joint is a separate problem in itself, being affected by such variables as can be grouped simply by "physical configuration of the joint", and those which can be described as "the welding process". The greatest single factor influencing the design of joints to reduce susceptibility of cracking is the matter of restraint by weld-metal contraction. The amount of restraint can be at least partially controlled by the joint geometry and sequence of welding, and the application of external heat to reduce temperature gradients. The items of *joint geometry* which can be varied are the root gap, scarf angle, land or lip, and the use of backing strips. The items in the *welding process* which can be varied are the size and shape of the weld bead, the amount of penetration, the welding speed and current, the electrode size, the electrode coating, and the sequence of welding. The effect of the mass – in particular the thickness of the joint section – can be altered by preheating.

The metallurgical factors associated with weld-metal cracking lie in an area where much more work must be done. The large number of variables in welding procedure and in composition makes it difficult to analyze and correlate results so that a general solution of the problem can be obtained.

In ferritic weld metal, the effect of various alloying elements showed the following tendencies:

1. Sulphur is the major factor causing hot cracking.
2. Silicon, oxygen and nickel increase susceptibility to hot cracking.
3. Manganese is beneficial in reducing hot cracking.
4. Vanadium reduces cold cracking when added to a highly hardenable weld metal. Although it is a grain refiner, it may be conducive to grain coarsening in over-heated weld metal (as in multipass welds).

In austenitic weld metals, the effects of the alloying elements and of the structures showed the following tendencies:

(Continued on p. 156)

what's new?

NO. 28 OF A SERIES.

flamatic hardens crankshaft bearings

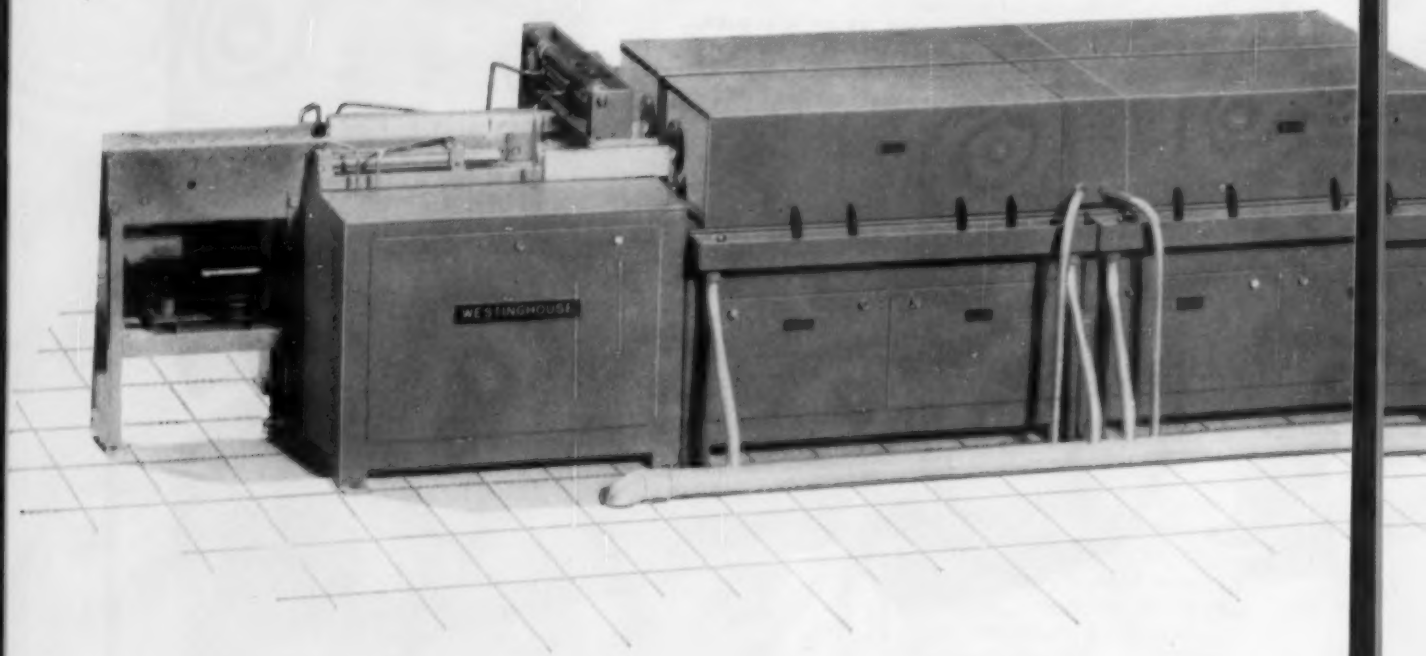
10/hr. to 70/hr.

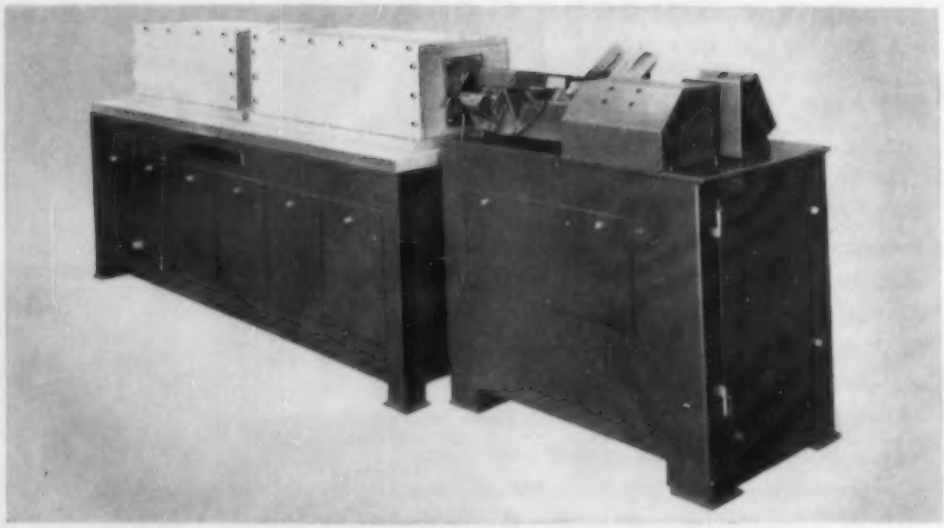
It's no wonder the automotive industry turns to **flamatic** for selective heating precision. This machine, for example, provides the flexibility for development work on a variety of crankshafts or small lot production up to 10 parts/hour, simultaneously hardens main and pin bearing diameters in one operation. Interchangeable flame heads, adjustable flame head holders, and movable tailstock permit quick changes from one size to another . . . Another **flamatic** hardening machine for one size crankshaft hardens 70 parts/hour. Single- or multi-purpose **flamatic** machines have met production requirements on many automotive parts, a number of which are shown at the right. Write for new **flamatic** catalog, Publication No. M-1861.

CINCINNATI **flamatic**

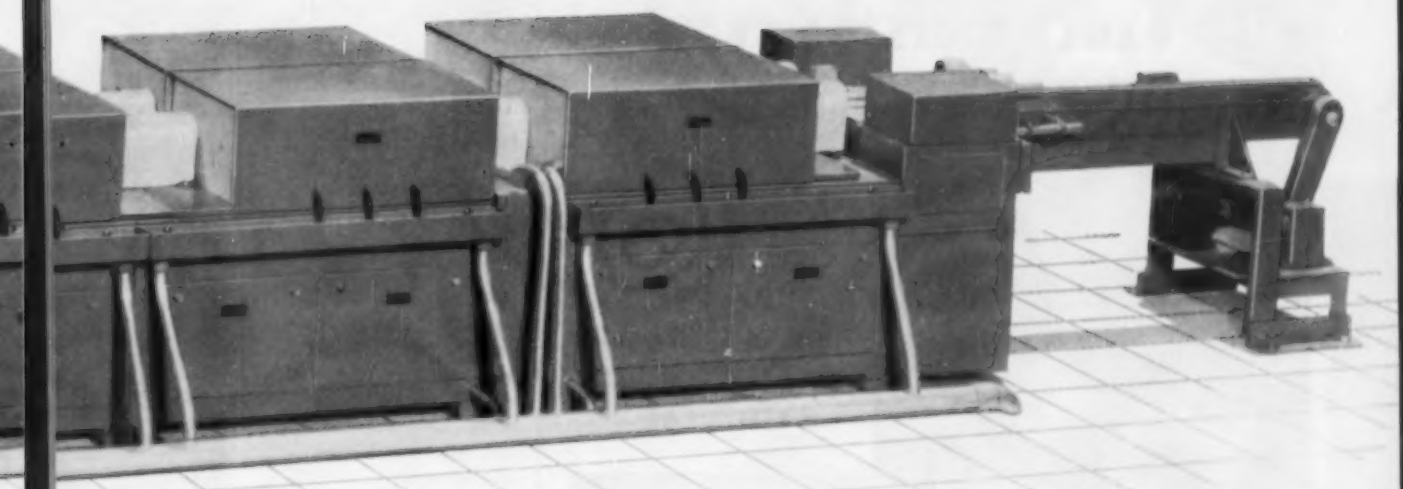
PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.

Dual-frequency heating at its best . . . the equipment shown here (using 60 and 960-cycle power) heats 3½" R.C.S. steel billets, 8" long, to 2150° forging temperature at a rate of 480 an hour. An actual installation, using six of these machines, heats 40 tons an hour!





Another outstanding example of Westinghouse dual-frequency induction heating for forging. Clean, cool, and safe, this billet heater takes only 4' x 8' of production floor area. Using dual-frequency power (60 and 960 cycles) it heats 2½" diameter, 3¾" steel billets to 2250° forging temperature at a rate of 360 per hour.



Boost forging rate 300%, cut costs 60%...

with Westinghouse induction heating

Based on a recent forging analysis, these figures tell dramatically what savings are being accomplished by Westinghouse induction heating compared to today's "old-fashioned" methods.

How? Here are seven big savings:

- Scale loss reduced to 6/10 of a percent—60 to 80% savings.
- Longer die-life because of low scale.
- Maintenance costs cut 80%.
- Scrap loss practically eliminated.
- Flexible to all production needs—short start-up time; stand-by losses are low or nonexistent. Accurate repetitive control of temperature.
- Shearing costs eliminated.
- Pushbutton operation—completely automatic—makes it practical to put forging right in the production line.

Westinghouse ingenuity is the key. Successful installations—some with even better savings—prove that two factors are vital to full benefit of induction heating . . . good equipment and expert application.

Westinghouse offers you a complete, one source service to analyze induction heating for *your* plant. Survey, recommendation, engineering and manufacturing—all by experienced Westinghouse personnel—assure you the proper frequency, power and method of handling to most effectively reduce costs in your plant.

Right now is the time to investigate. You can lead the way to lower break-even points, decreased unit costs—point to extra profit possibilities—by bringing Westinghouse into your forging picture. Call your representative or write: Westinghouse Electric Corporation, H. F. Heating Section, 2519 Wilkens Ave., Baltimore 3, Maryland. J-02292-B

INDUCTION HEATING FOR HARDENING • JOINING • ANNEALING FORGING • HEAT-TREATING

YOU CAN BE SURE...IF IT'S Westinghouse

You can have DRY AIR with exact moisture control

ASSEMBLING ELECTRONIC PARTS

FOR YOUR COMFORT
FOR YOUR PROCESS
FOR TESTING MACHINES OR MATERIALS AT ANY TIME OF THE YEAR

PACKAGING FOOD PRODUCTS

● This Niagara "Controlled Humidity" method gives you the **MOST EFFECTIVE** Air Conditioning because its cooling and heating functions are made completely separate from adding or taking away moisture. This assures you always a precise result. No moisture sensitive instruments are needed.

MOST FLEXIBLE. You can reach and hold any condition in response to instrument settings, or vary it as you wish.

EASIEST TO TAKE CARE OF. The machine is accessible, the control circuits are simple and easy to operate, and there are no solids, salts or solutions to be handled.

MOST COMPACT. It does a very large amount of work in a small space.

INEXPENSIVE TO OPERATE. At normal atmospheric temperatures (unlike systems that use refrigeration to dehumidify) it needs no summer re-heat.

DRYING INDUSTRIAL MATERIAL

Write for Bulletins 112 and 122

NIAGARA BLOWER COMPANY

DEPT. MP , 405 LEXINGTON AVE. NEW YORK 17, N. Y.

Niagara District Engineers in Principal Cities of U. S. and Canada

Weld Cracking . . .

1. Columbium, phosphorus, sulphur, nickel and copper increase susceptibility to hot cracking.

2. Silicon increases susceptibility to fissuring.

3. Molybdenum and chromium reduce hot cracking.

4. Delta ferrite, in amounts up to 10%, makes austenitic weld metal less sensitive to hot cracking. The amount of delta ferrite is controlled by adjusting composition of the melt so that the ferrite forming elements exceed the austenite forming elements. Formulas and diagrams have been developed so the percentage of delta ferrite can be computed. The mechanism by which delta ferrite reduces the weld-metal cracking tendency is not known.

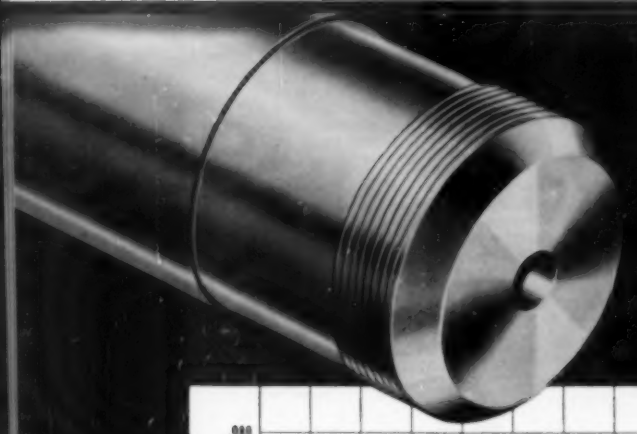
In studying the causes of weld-metal cracking, many investigators devised methods for measuring the hot ductility and hot strength of weld metal. Most of these measurements were obtained on reheated samples rather than samples cooling from the solidification temperature. Some of the early tests on the hot ductility indicated that FeO was the cause of hot shortness of weld metal when tested at 1650° F.

High-temperature investigations of ductility were carried out at Battelle Memorial Institute in the range of 2100 to 2400° F., wherein the hot shortness temperature was determined by the character of the tension test fracture as it changed from ductile to nonductile. From this test it was shown that Type 316 and 349 deposits in Timken alloy and in Vitallium were hot short above 2250° F., yet the approximate hot shortness temperature of the core wires used in these welds was above 2400° F. Other results on hot bend tests of high-temperature alloys indicate that the weld metals were hot-short in the vicinity of 2325° F.

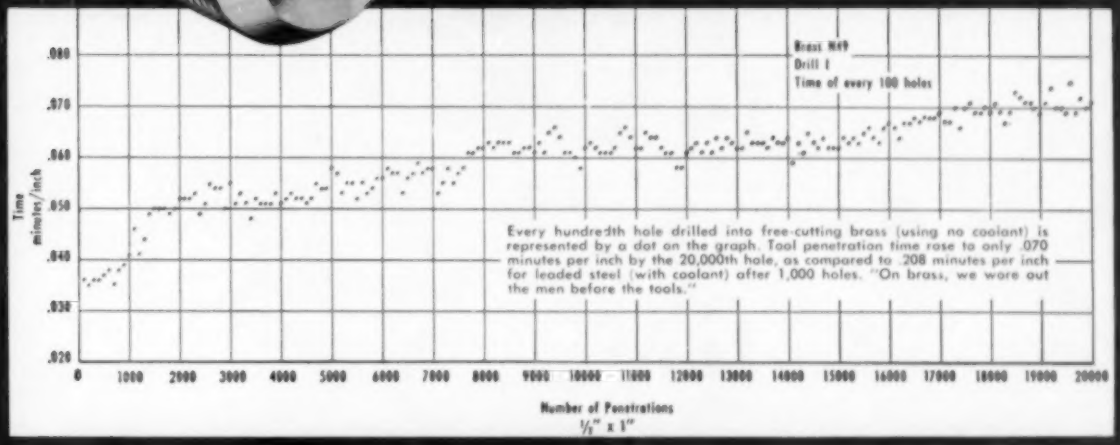
Cracking of weld metal which occurs below the transformation temperature of the alloy can be attributed to the blue brittleness phenomenon. It was observed that the blue brittleness of weld metals increased with the nitrogen content. The temperature range producing the maximum effect is 800 to 1000° F.

E. F. Ebling

(To be concluded next month)



Left—condition of drill after 1,000 holes in leaded steel (with coolant); right—condition of drill after 20,000 holes in free-cutting brass (no coolant).



exhaustive 20,000-hole drill test proves superior machinability of brass rod...

Is leaded steel as machinable as brass?

Lack of scientific machining data comparing these two metals prompted Titan to launch extensive research—not only in the laboratory but on the production line.

In a closely-controlled Constant Pressure Drilling Test using no coolant, the time to drill a ½"-diameter, 1"-deep hole in leaded steel increased 93.5% by the 200th hole. Penetration time for brass had increased only 6.45%. On this basis, brass was 14 times more machinable.

But Titan metallurgists went further. In an exhaustive effort to wear the drilling tool on brass to the same extent that 1,000 holes in leaded steel (with coolant) had worn it, a total of 20,000 holes were drilled in brass (using no coolant). Penetration time was only .070 minutes per inch for brass *after 20,000* holes as compared to .208 minutes per inch for leaded steel *after 1,000 holes*.

It was impossible to wear out the tool drilling 20,000 holes in brass. The test was stopped. "We wore out the men instead."

Read about Titan automatic screw machine production results comparing brass and leaded steel booster bodies. Send for free 48-page booklet titled "First Report." Use coupon below:

Dept. F

Titan Metal Mfg. Co., Bellefonte, Pa.

Gentlemen: Please send free booklet titled "First Report" about brass machinability.

Name_____

Title_____

Company_____

Street_____

City & State_____

Titan

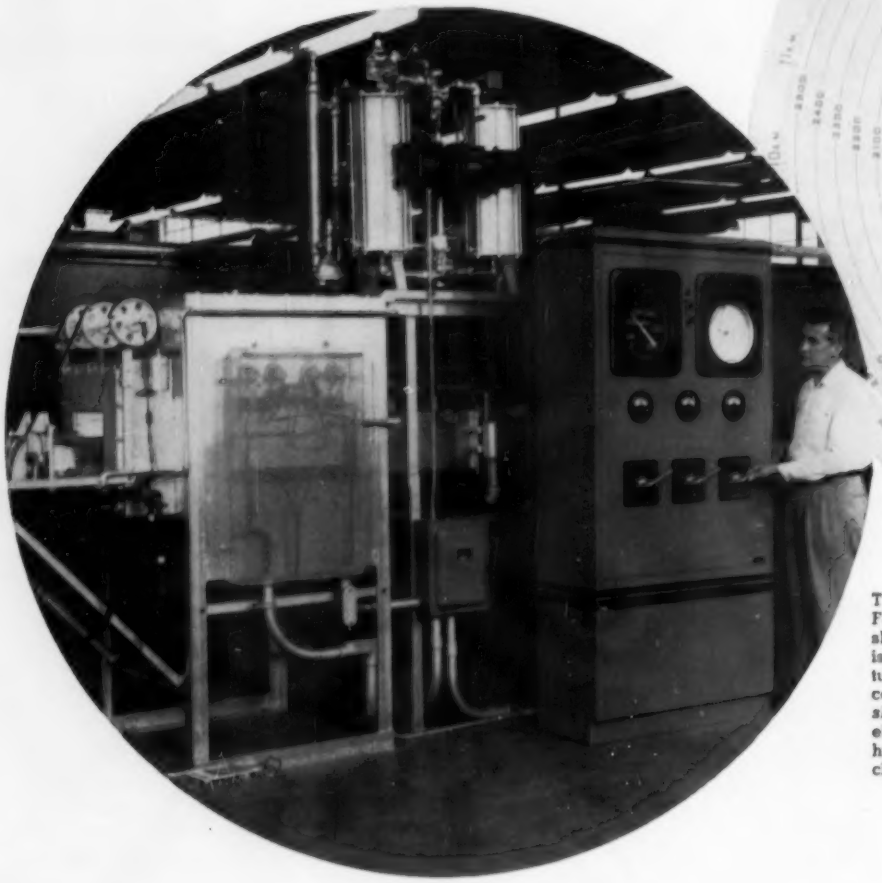
METAL MANUFACTURING COMPANY

Bellefonte, Pa. Offices and Agencies in Principal Cities

RODS · FORGINGS · DIE CASTINGS · WELDING RODS · WIRE Quality Alloys by Brass Specialists

Furnace Temperatures "Toe the Line"!

. . . under new Foxboro Electric Proportional Control



This typical chart from Foxboro M/81b Controller shows how furnace (left) is brought up to temperature and precisely held at control point *without* over-shoot. Installation is on electric furnace hardening high-precision, small machined parts.

Heat treating temperatures stay right on the control line when the new Foxboro M/81b Electric Proportional Controller handles furnace heat input. This fast-acting Controller assures the furnace a "balanced diet" of B.T.U.'s despite upsets, load changes, furnace lags, or ambient temperatures.

Control action is simple — effective. The M/81b senses any tendency of temperature to move away from pre-set control point . . . automatically varies ratio of heat "time-on" to "time-off" depending on changes in furnace loading. This *Proportional-set Average-position Controller* eliminates over- and under-shoot . . . maintains unusually uniform furnace conditions.

For top performance from your electrically heated or fuel-fired muffle-type furnace . . . new or modernized . . . investigate Foxboro Electric Proportional Control. Write for Bulletin 4-11.

THE FOXBORO COMPANY, 522 NEPONSET AVENUE, FOXBORO, MASSACHUSETTS, U. S. A.

FOXBORO
REG. U. S. PAT. OFF.

Electric
Proportional Controllers

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Photo courtesy John A. Roebling's Sons Corp.

This wire is lightly scaled steel, at 400 F. It's passing through a 15-20% sulfuric-acid pickling bath at 100′ per min. Where the wires bear – along the edge of the tank, and down in the acid bath – special wear-resistant surfaces are required. You can imagine the punishment they take . . . from the semi-scaled steel; the fast moving wire; the hot acid. In fact, most materials would be sliced through in a matter of days.

One exception is a hard (almost diamond-hard), "man-made mineral", CARBORUNDUM's silicon carbide. Acids don't bother it. Nor does the worst imaginable abrasion or erosion. In the photo above, you can see how little effect six months' service have had on this wear stone. Even the acid-submerged silicon carbide wear stone has not started to groove.

There's just no comparison with other materials. Used under the toughest wear-and-tear conditions known (e.g. linings for cyclone dust collectors, coke chutes, furnace skid rails, etc.), silicon carbide has many times the life of alloys or other commercial materials. Try it – and see for yourself how well it works under severe abrasive service.

As a starter, send for your copy of *"Super Refractories in Heat Treatment Furnaces."* No obligation, of course.

CARBORUNDUM

Registered Trade Mark

Dept. V25, Refractories Div., Perth Amboy, N. J.

Fatigue-Induced Micrographic Changes in Pure Aluminum*

THIS is a continuation of a previous study of the process of slip under fatigue stresses (*Journal* of the Institute of Metals, Vol. 80, 1951-52, p. 181). In the present work the surface topography of electropolished 99.99% purity aluminum was examined with an electron microscope and with a light microscope by the method of multibeam interferometry.

Static deformation of a single crystal of aluminum produced slip bands which appeared in the interferometric fringe pattern as sawtoothed fringes; this indicated that the slip displacement was accompanied by a rotation of the crystal. After a subsequent straining in a direction opposite to that originally used, the fringe pattern of the surface showed that the bands were now grooves of almost the same depth as the former steps. It thus appeared that very little slip occurred on the original planes.

A similar groove-type formation was found when a single crystal was cyclically stressed at a frequency of 6000 cycles per min. The bands were fairly regularly spaced along the specimen, their density increasing slightly toward the fixed end of the cantilever-type specimen. New bands were formed close to the initial ones as the cycling was continued, and although striations were produced, the original spacing of the slip bands was maintained. Each successive reversal did not necessarily produce new bands but the striations grew steadily during the fatigue life.

Kink bands, characterized by the absence of visible slip under the light microscope, were also observed. Interferometric examination revealed that even these apparently "slipless" regions are corrugated. These corrugations might have been due to the very fine slip found subsequently with the electron microscope or possibly to elastic internal strains.

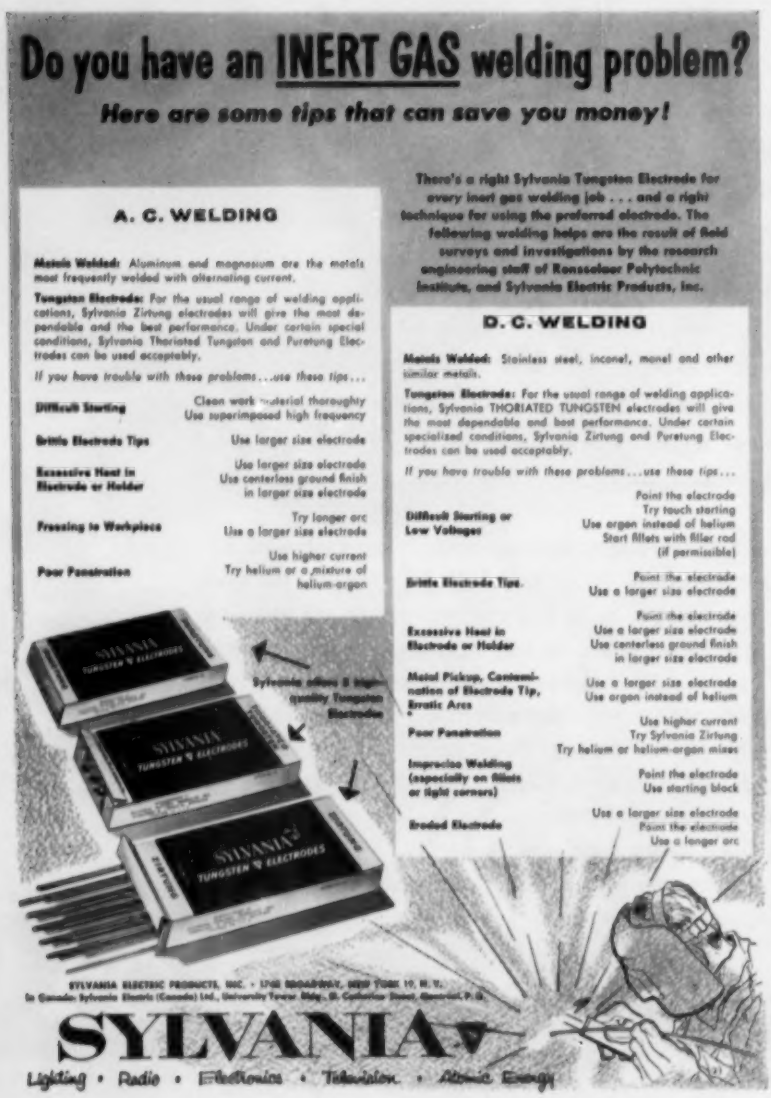
Specimens of polycrystalline pure aluminum were "cycled" at 6000 cycles per min. and the striations and kink bands were examined more thoroughly with the electron microscope. The main feature was that the individual slip bands within a striation contained many finer bands. Even the so-called "slipless" regions were covered with lamellae so fine that they could be detected only with the electron microscope. The existence of very fine cross slip and regions of high lattice curvature could also be confirmed.

Similar specimens were cyclically stressed at about 20,000 cycles per min. on a resonance-type fatigue machine. Here the striations were more definite and often very straight and continuous across any particular grain. They consisted of ridges and shallow channels which often had short cracks along the bottom. Grain boundary migration and crossing of such boundaries by propagating striations were also noticed. Fewer regions of local curvatures were found at these high frequencies.

Similar experiments were later performed on test specimens of cast silver chloride to study the initiation of fatigue cracks and the part played by crystallite boundaries in this process. After the slip bands were removed by dissolving away the surface layer, small cracks were visible at the boundaries of the small crystallites formed by fatigue stressing. Forsyth's earlier work had suggested that the same phenomenon occurred

(Continued on p. 160)

*Digest of "Some Further Observations on the Fatigue Process in Pure Aluminum", by P. J. E. Forsyth, *Journal* of the Institute of Metals, Vol. 82, 1953-54, p. 449-455.


Do you have an INERT GAS welding problem?
Here are some tips that can save you money!
There's a right Sylvania Tungsten Electrode for every inert gas welding job . . . and a right technique for using the preferred electrode. The following welding helps are the result of field surveys and investigations by the research engineering staff of Rensselaer Polytechnic Institute, and Sylvania Electric Products, Inc.
A. C. WELDING
Metals Welded: Aluminum and magnesium are the metals most frequently welded with alternating current.
Tungsten Electrode: For the usual range of welding applications, Sylvania Zirtung electrodes will give the most dependable and the best performance. Under certain special conditions, Sylvania Thoriated Tungsten and Puretung Electrodes can be used acceptably.
If you have trouble with these problems...use these tips...
Difficult Starting — Clean work material thoroughly; Use superimposed high frequency
Brittle Electrode Tips — Use larger size electrode
Excessive Heat in Electrode or Holder — Use larger size electrode; Use centerless ground finish in larger size electrode
Fussing in Workpiece — Try longer arc; Use a larger size electrode
Poor Penetration — Use higher current; Try helium or a mixture of helium-argon
D. C. WELDING
Metals Welded: Stainless steel, inconel, monel and other similar metals.
Tungsten Electrode: For the usual range of welding applications, Sylvania THORIATED TUNGSTEN electrodes will give the most dependable and best performance. Under certain specialized conditions, Sylvania Zirtung and Puretung Electrodes can be used acceptably.
If you have trouble with these problems...use these tips...
Difficult Starting or Low Voltages — Point the electrode; Try touch starting; Use argon instead of helium; Start fillets with filler rod (if permissible)
Brittle Electrode Tips — Point the electrode; Use a larger size electrode
Excessive Heat in Electrode or Holder — Point the electrode; Use a larger size electrode; Use centerless ground finish in larger size electrode
Metal Pickup, Contamination of Electrode Tip, Erratic Arcs — Use a larger size electrode; Use argon instead of helium
Poor Penetration — Use higher current; Try Sylvania Zirtung; Try helium or helium-argon mixes
Imprecise Welding (especially on fillets or tight corners) — Point the electrode; Use starting block
Eroded Electrode — Use a larger size electrode; Point the electrode; Use a longer arc
Sylvania offers 5 high-quality Tungsten Electrodes
SYLVANIA
SYLVANIA ELECTRIC PRODUCTS, INC. • 1740 BROADWAY, NEW YORK 19, N. Y.
SYLVANIA
Lighting • Radio • Electronics • Television • Atomic Energy

Cut metal-treating costs 55% with Armour Ammonia!

This cost comparison chart illustrates how you can make this great saving by switching to pure, dry Armour Ammonia, as a source of hydrogen!

	HYDROGEN	ARMOUR AMMONIA	REMARKS
Delivered base price	$2.00 per cyl.	$18.50 per cyl.	
Volume per cylinder	200 cu. ft.	4500 cu. ft.	After dissociation
Equivalent number of cyls.	23	1	
Handling labor (5¢/cyl.)	$1.15	$.05	
Storage cost (4¢/cyl.)	.92	.04	
Handling labor/100 cu. ft.	.025	.001	
Storage cost/100 cu. ft.	.020	.001	
Cost of product/100 cu. ft.	1.00	.410	
Cost of equipment/100 cu. ft.	—	.125*	Amortized in 3 years
Cost of electric power/100 cu. ft.	—	.060	
Total cost/100 cu. ft.	$1.045	$.597	
Savings in operation/100 cu. ft.		.448	

Percentage savings in operation cost 44%

and after equipment is amortized, savings are . . 55%†

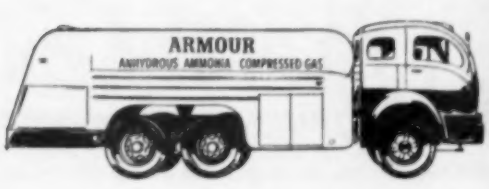
*This figure arrived at by the following assumption: 500 cu. ft.- per hour dissociator costs approximately $4500 installed. Assume equipment to be completely amortized in 3 years, then amortized cost of equipment equals $.125 per 100 cu. ft.

DATA COURTESY THOMAS GAS CONTRACTORS, WESTFIELD, N. J.

Let Armour Help Solve Your Metal Treating Problems

Manufacturers get more than ammonia when they specify Armour. Since 1947 Armour has sponsored a fellowship at a leading technological university for the study of metal treating processes using ammonia. The results of this research are available to you. Furthermore, the men of the Armour Technical Service Department are equipped to handle and answer any problems arising with ammonia installations for metal treating. Write today for free copies of the booklets offered at right. If your problems are unusual or pressing, write, giving full details.

†Additional savings are possible when you order tank truck quantities—service available in most areas.



CLIP AND MAIL THIS TODAY!

Please send me free copies of the booklets which I have checked:

- ☐ "Ammonia Cylinder Installations for Metal Treating"
- ☐ "Effective Use of Dissociated Ammonia"
- ☐ "Case Hardening of Steel by Nitriding"
- ☐ "A Survey of Industrial Carbonitriding Practice"
- ☐ "Investigation into the Carbonitriding of Plain Carbon Steel"
- ☐ "The Carbonitriding of Alloy Steels"
- ☐ Tank truck service information

Name ..... *Title* .....

Firm .....

Address .....

City ..... *Zone* .... *State* .....

P 2

ARMOUR

Ammonia Division

Armour and Company • 1355 W. 31st Street • Chicago 9, Ill.

Fatigue in Al . . .

in pure aluminum, although this could not be substantiated.

The ensuing discussion emphasizes the observation that a reversal of the direction of the applied force causes slip on new planes and not on the original ones. (This fact, in the reviewer's knowledge, has been known and accepted since the time of Ewing and Humfrey, 1903. Otherwise one could not explain the increasing density of slip bands under repeated reversals of stress of constant amplitude.) The author then points out that large rotation of crystals is unlikely in polycrystalline material because of the restraint imposed by neighboring grains. The origin of the formation of kink bands is interpreted in terms of movements of lattice curvatures (after Jillson) and piling up of dislocations (after Mott).

Forsyth seems to attach much value to a tint, or what appears to be a granular oxide film, that forms along the pronounced striations which result after fatigue stressing at high frequency. A similar effect was found earlier on iron and copper, and the author suggests that this film may be a manifestation of a considerable rise in local temperature which would cause thermal softening with attendant lowering of the cohesive strength of the metal. Even though a general work hardening of the specimen may be found, he considers that work hardening and embrittlement are not the causes of fatigue cracking.

The reviewer believes that acceptability of the thermal softening concept is dependent on whether an appreciable fall of the endurance and fatigue limit occurs as a result of increasing the loading frequency. The available evidence indicates that an opposite effect occurs.

This paper contains many interesting factual observations; however, these can be appreciated only if one can refer to the numerous illustrations and photographs it contains.

N. H. POLAKOWSKI

Efficiency in Cutting-off is Important

Practically all machining operations start with pieces cut-off from bars or billets. Hence, inefficiency, or lack of capacity, in the cut-off department can hold up or stagnate the entire plant.

A. Are all-ball-bearing and provide a quick return; therefore they run FASTER than others on the same work.

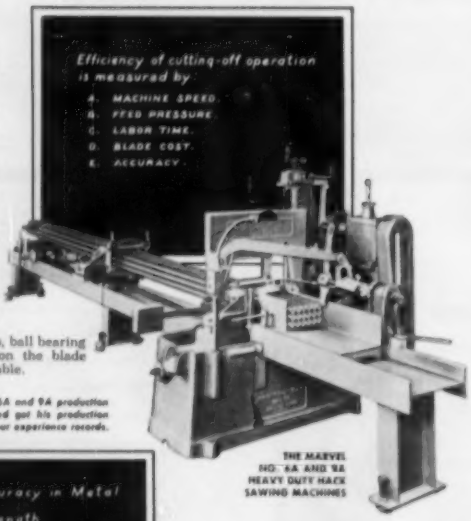
B. Can apply as much as 1200 pounds feed pressure—two to ten times as much as other hack saws and band saws.

C. Are fully automatic, requiring no more operator attention than an automatic screw machine; and set-up for any bar size and cut-off length is extremely simple.

D. Use a non-breakable high speed hack-saw blade — the type of saw blade that produces the greatest number of square inches of metal cut per dollar of blade cost—two to ten times (or more) as much as any band saw.

E. Because of their exceptional sturdiness, ball bearing reciprocating frame, ability to tension the blade "truly taut", their accuracy is dependable.

If you are not using modern, improved MARVEL NO. 6A and 9A production hack saws, call the local MARVEL Field Engineer and get his production and cost estimates on your work—to compare with your experience records.



THE MARVEL NO. 6A AND 9A HEAVY DUTY HACK SAWING MACHINES

Formula for Accuracy in Metal Sawing
ACCURACY = (Length, Straightness, Squareness)
Straightness, Squareness) = (Blade Rigidity, Blade Toughness)
MARVEL

Write for catalog C-55—showing and describing eleven different series of Metal Cutting Sawing Machines and MARVEL High Speed-Edge Hack Saw Blades and Hole Saws.

The composite MARVEL High-Speed-Edge Hack Saw Blade—cuts **any** machinable material efficiently. There is no time lost changing blades for different types of steel; no time lost replacing shattered blades, because MARVEL High-Speed-Edge Hack Saw Blades are positively **unbreakable.** These superior blades have the finest high speed steel cutting edge welded to a strong alloy steel body. They will stand-up under the highest **speeds** and **heaviest feeds** attainable on any make hack saw. Can be safely tensioned tauter than any other blade—cut-off not only straight but also square and with less stock loss.

MARVEL Metal Cutting SAWS

ARMSTRONG-BLUM MFG. CO. 5700 West Bloomingdale Avenue • Chicago 39, U.S.A.

Spot Welding of Titanium*

THIS PAPER summarizes the work done at the Thomson Laboratory of the General Electric Co. in evaluating the spot welding characteristics of titanium sheet. The materials investigated included: Ti-75 A, RC-55, RC-70, Ti-100 A and RC-130 A. All welding was done with press-type equipment using conventional single-phase alternating current at either 100 or 200 kva. and with synchronous thyratron control. Cross-sectional studies, tensile shear, tensile pull-out, and fatigue tests were used to evaluate the spot welds.

Spot welds of 0.060-in. thick Ti-75A material gave tensile shear values of 2700 lb. as compared to a 2600-lb. average required by the Thomson Laboratory specifications for this thickness and strength of material. The 0.094-in. RC-55 sheet showed 5800 lb. tensile shear strength compared to a 4960 lb. specified average. Failures were of the "button" type wherein the parent metal tore away from the weld. This kind is more desirable than a shear failure where fracture occurs through the weld at the mating surfaces.

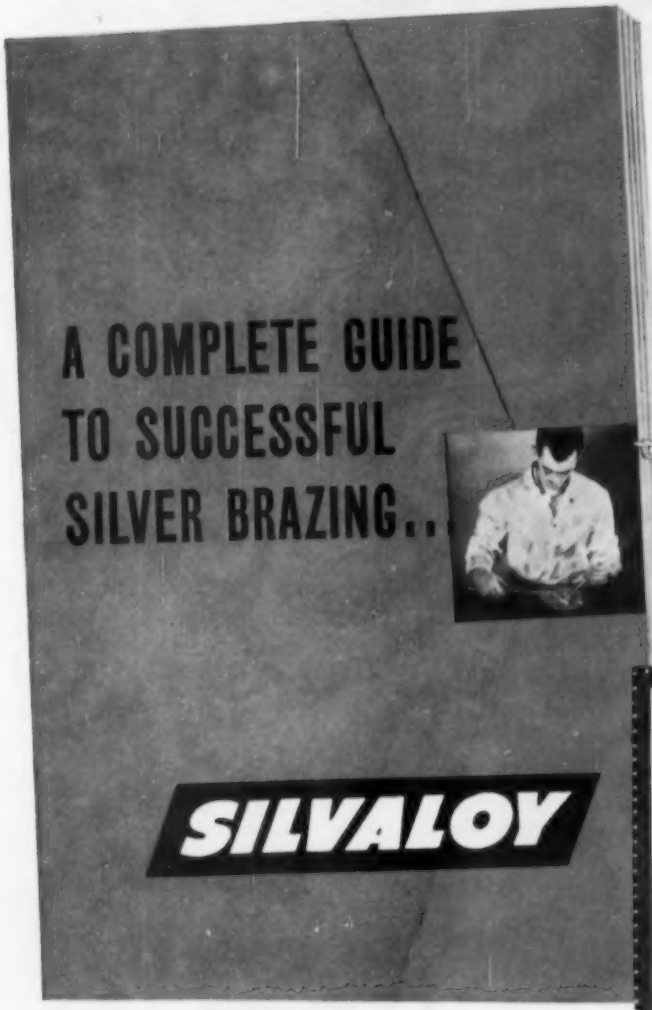
Initial spot welding tests on RC-70 and Ti-100 A indicated that spot welds could be made readily, although the failure appeared to be of lower ductility than with RC-55 and

(Continued on p. 162)

*Digest of "Resistance Spot Welding of Titanium and Its Alloys", by A. J. Rosenberg, *Welding Journal*, Vol. 33, April 1954, p. 324-328.

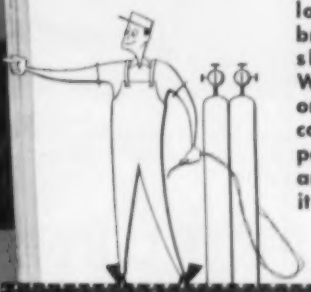
128,000

COPIES OF THIS MANUAL HAVE BEEN SENT UPON REQUEST...



We knew a thorough, careful and complete job had been done when our 56-page pocket-size "COMPLETE GUIDE TO SUCCESSFUL SILVER BRAZING" was completed and offered to those interested in the subject.

It is therefore rewarding to have received requests for more than 128,000 copies from production men, engineers, maintenance units of the Armed Services, welding schools, libraries, etc. We are proud and pleased to have such overwhelming evidence that the booklet is a practical, informative, highly useful reference work.



If you are interested in low-temperature silver brazing, certainly, you should have a copy. We'll be happy to send one to you. Fill-in the coupon — paste it on a postcard or enclose it in an envelope and return it to us.

THE AMERICAN PLATINUM WORKS, INC.
231 New Jersey Railroad Avenue Newark 5, New Jersey

Gentlemen: Please send me a copy of "A COMPLETE GUIDE TO SUCCESSFUL SILVER BRAZING." I understand that this will be sent without charge or obligation.

NAME.....

COMPANY.....

STREET.....

CITY..... ZONE.....

STATE.....

THE AMERICAN PLATINUM WORKS

231 NEW JERSEY RAILROAD AVENUE • NEWARK 5, NEW JERSEY

Manufacturers of Silver Brazing Alloys and Fluxes • Distributors throughout the United States and Canada

Welding Titanium . . .

Ti-75 A. In the hope of improving this condition, the effects of weld times from 3 to 20 cycles were investigated, adjusting the current to produce welds of constant diameter. Although no differences in weld strength or fracture appearance could be found, it was noted that the heat-affected zone was reduced by short welding times. Since a reduced heat-affected zone was desirable, 8 cycles was chosen for all further testing as a compromise between consistency of results and welding time.

The tensile shear strength of 0.062-in. thick RC-70 was investigated as a function of weld diameter. Figure 1 summarizes the results obtained in comparison with similar values for Type 347 stainless steel and low-carbon steel. In general, these values are comparable with the strength of the materials, RC-70 showing the highest values followed by Type 347 stainless and low-carbon steel.

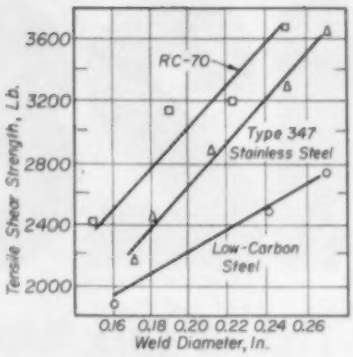


Fig. 1 – The Tensile Shear Strength Versus Weld Diameter for Spot Welds on 0.062-In. Thick Samples

To obtain additional comparable data, similar tests were made with tensile pull-out specimens where the specimen is loaded so that the weld is subjected to a straight tensile load. In this test the titanium had strengths substantially below both Type 347 and low-carbon steel; see Fig. 2.

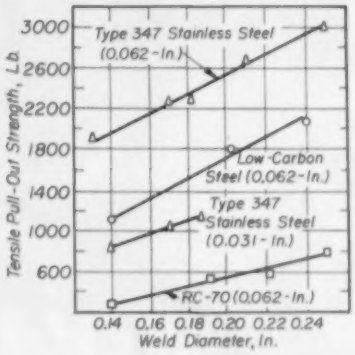
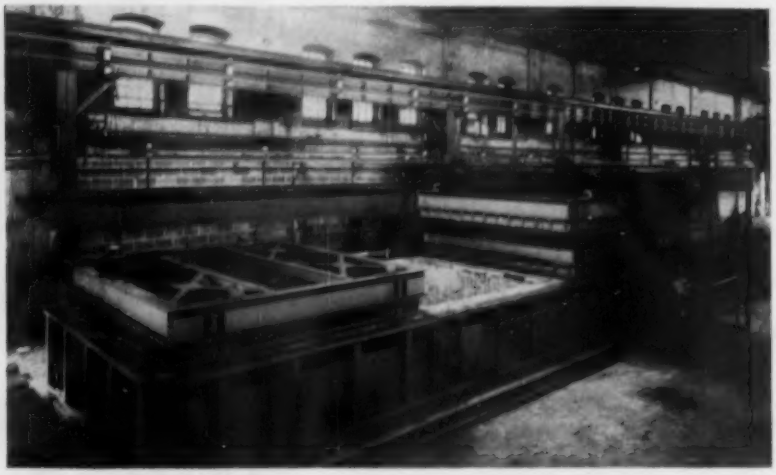


Fig. 2 – The Tensile Pull-Out Strength Versus Weld Diameter

This tendency toward subnormal performance for titanium spot welds was further indicated by fatigue tests of 0.094-in. thick Ti-100 A. Data for these are summarized in the modified Goodman diagram, shown in Fig. 3, for several conditions of static and dynamic stress. The significant feature of this plot is the slope of the line on the ratio of fatigue strength at zero static load to shear strength. This ratio for Ti-100 A is

(Continued on p. 164)



Four R-S Pit Furnaces used as soaking pits for preheating. Oil-fired. Maximum temperature of 2000° F. Capacity of each—33,000 pounds of steel ingots per hour. Size—10′ 6″ square and 7′ 6″ deep.

PIT TYPE FURNACES

R-S Pit Type Furnaces are batch furnaces with a movable top through which work may be loaded and unloaded. They are furnished as direct-fired units for temperatures from 1000° F. to 2500° F. or forced convection units from 600° F. to 1400° F., using oil, gas or electricity. There are no size limitations on charge weight or length and depth of work heating chamber. Width is normally limited in order to keep the pit covers within reasonable limits. Circular pits are available as well as the rectangular variety.

This type of furnace is used to heat metal for forging, rolling and forming operations in both the ferrous and nonferrous fields.

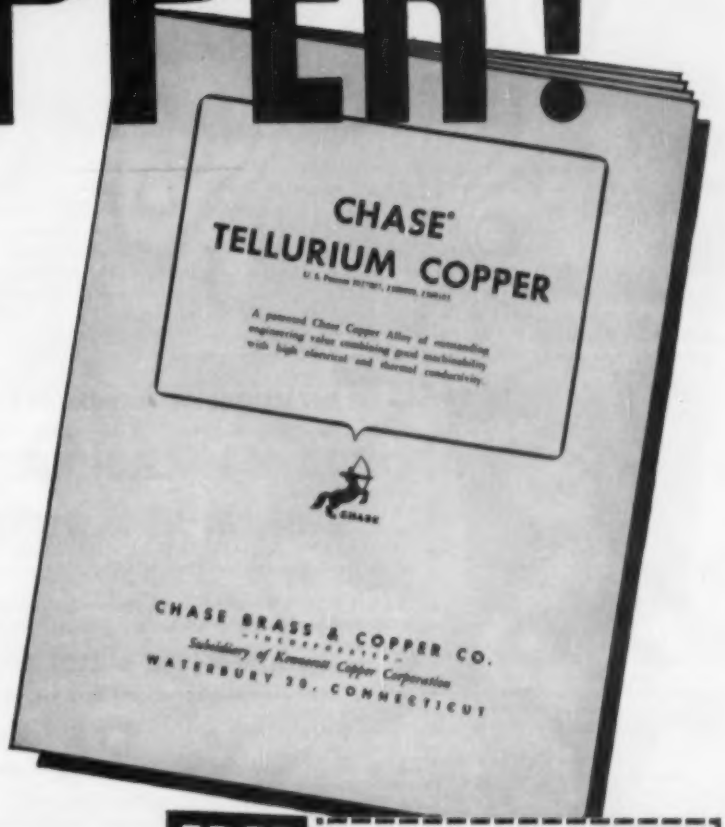
Write today for Bulletin No. 200 describing the complete line of R-S Furnaces for metal heating and heat treatment.

R-S FURNACE CORP.
4555 GERMANTOWN AVENUE
PHILADELPHIA 44, PENNSYLVANIA

A SUBSIDIARY OF
HARDINGE COMPANY, INC.

R-S
QUALITY FURNACES SINCE 1900

TELLURIUM COPPER!


CHASE®
TELLURIUM COPPER
A patented Chase Copper Alloy of outstanding engineering value combining good machinability with high electrical and thermal conductivity.
CHASE
CHASE BRASS & COPPER CO.
Subsidiary of Kennecott Copper Corporation
WATERBURY 20, CONNECTICUT

Has high conductivity, good machinability... saves production time!

Chase Tellurium Copper gives you the advantages of high conductivity *plus* good machinability.

Chase Tellurium Copper can be machined with tool speeds and settings similar to those used with Free-Cutting Brass, permitting high rates of production. But, unlike Free-Cutting Brass, Chase Tellurium Copper can be *hot worked* easily, and can be cold worked almost as extensively as pure copper.

For more information on Chase Tellurium Copper, check the coupon below.

Chase®
BRASS & COPPER CO.
WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION
The Nation's Headquarters for Brass & Copper

Albany†	Chicago	Detroit	Los Angeles	New York	St. Louis
Atlanta	Cincinnati	Grand Rapids†	Milwaukee	Philadelphia	San Francisco
Baltimore	Cleveland	Houston	Minneapolis	Pittsburgh	Seattle
Boston	Dallas	Indianapolis	Newark	Providence	Waterbury
Charlotte†	Denver	Kansas City, Mo.	New Orleans	Rochester†	(Sales office only)

FREE

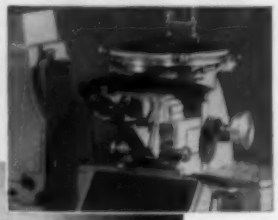
Chase Brass & Copper Co.
Waterbury 20, Conn.
Dept. MP-255

Gentlemen:
Please send me your free Tellurium Copper booklet.

Name_____
Position_____
Firm_____
Street_____
City_____ State_____

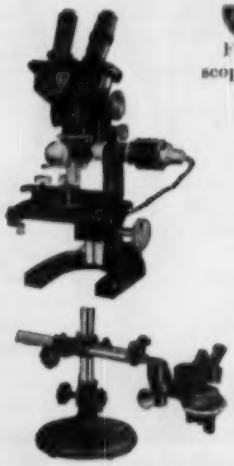
A COMPLETE LINE OF

PRECISION INSTRUMENTS for Metallographers



AO CONTROL AND RESEARCH METAL-LOGRAPHS

● Years ahead in optical quality and simple, rapid operation, these two AO Metallographs outperform the field. Every operation is accomplished while you sit comfortably at a modern desk . . . you compose the picture on a screen directly in front of you . . . focus the camera automatically while examining the specimen through the microscope . . . take notes, change magnification, adjust the lamp, make the exposure—all with unbelievable speed, ease, and precision. Other features: monocular or binocular bodies, revolving objective turret, two lamps—visual and photographic, "autofocus" coarse adjustment stop. For those laboratories needing an instrument for the study of anisotropic materials, the AO Metallograph equipped with a circular revolving stage and polarized, phase, and bright field illumination, is recommended.



SPENCER METALLURGICAL MICROSCOPES

From the complete line of Spencer Metallurgical Microscopes, select an instrument that exactly meets your needs.

- AMERICOTE OPTICS eliminate reflections, provide added contrast.
- WIDE RANGE ADJUSTABLE STAGE handles unusually large or small specimens.
- BRILLIANT, UNIFORM ILLUMINATION from a vertical illuminator that is simple to operate, sturdy, cool.
- VARIETY OF EQUIPMENT for teaching, routine examinations, and research.

SPENCER STEREOSCOPIC MICROSCOPES

Two distinct advantages are offered by these instruments:

1. The image is erect and a wide field of view is provided.
2. The image has depth and shows the specimen in three-dimensional perspective.

No. 26 is designed for examining small specimens.

No. 23 (illustrated) for large objects. No. 353 Illuminator provides an adaptable source of illumination.

American Optical
INSTRUMENT DIVISION

Name

Address

City

State

Please send me complete information on
- ☐ Control Metallograph
- ☐ Research Metallograph
- ☐ Metallurgical Microscope
- ☐ Stereoscopic Microscope

Welding Titanium . . .

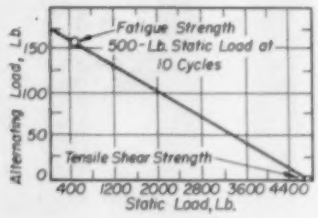


Fig. 3 – Static Load Versus Dynamic Load at 10,000 Cycles for Spot Weld on 0.94-In. Ti-100A

less than 4%. For other structural materials this ratio ranges from 5.8 for low-carbon steel to 10% for the 24 S-T aluminum alloy.

However, the author reports that design engineers are aware of the limitations of titanium spot welds, have overcome these disadvantages, and both RC-70 and Ti-100 A have been fabricated into components involving spot welding.

Since the high-strength titanium alloy (RC-130 A) is a two-phase alloy subject to embrittlement when rapidly cooled from above the all-beta temperature, and since such quenching is inherent in spot welding, initial tests of spot welds showed that the welds failed abruptly in tensile shear with little or no plastic deformation. Other work at Thomson Laboratory on the heat treatment of fusion welds in RC-130 A indicated that some benefit might be obtained by heat treating (1500° F. for 5 min. and furnace cooling) to restore ductility. Although tensile shear and tensile pull-out tests both show that such heat treatment did improve weld properties, the values obtained were no better than those obtained for RC-70. Also, the tensile pull-out tests gave values substantially below those obtained with Type 347 stainless steel and low-carbon steel.

This work is summarized as follows:

"The commercially pure grade of titanium and the medium-strength alloy materials have shown themselves to be readily spot welded. Tensile shear strengths are equal to or greater than that of welds in equivalent thicknesses of austenitic stainless steels. Direct tensile strength and fatigue levels are somewhat low and these facts must be

(Continued on p. 166)

Case No. 42

Kemp Immersion Heating Gets Top Results for Signode Steel Strapping Company

How Signode Steel Strapping Co. tempers 650 feet of steel strap every minute

At the Signode plant in Sparrows Point, Md., turning out up to a thousand miles of steel strap daily calls for fast, efficient production line techniques. One highly important phase in the final processing is the tempering bath. Here, Signode called on Kemp Engineers to supply the 15 ton, gas-operated Immersion Melting Pot shown above. Now steel strap is uniformly tempered at the rate of 650 feet per minute.

Kemp Offers More Advantages

By installing Kemp Immersion Heating, Signode benefits in many ways. Unlike underfired pots, Kemp pots are *not* subject to *periodic* and expensive shutdowns . . . won't crack or break. They operate *continuously* at maximum heating efficiency with a ***substantial*** savings in fuel costs. Offer a greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures. At the same time, this Kemp unit enables Signode to eliminate costly temperature override and open flame fire hazards.

Let Kemp Solve Your Problems

These same advantages apply to all types of melting or heating operations. Whether you are engaged in tempering, annealing, descaling, coating, etc., you can rely on Kemp Immersion Heating. Why not find out how Kemp Engineers can help you, save you money?

This 10 ton oval pot is typical of the many Kemp installations now in use. Features Kemp Carburetor, part of all Kemp equipment, to deliver complete combustion . . . without waste . . . without fluttering. One-pipe air and fuel feed reduces installation costs, simplifies maintenance.

For more complete facts and technical information, write for Bulletin IE 11 to C. M. KEMP MFG.CO., 405 East Oliver St., Baltimore 2, Maryland.

KEMP OF BALTIMORE

IMMERSION MELTING POTS

CARBURETORS • BURNERS • FIRE CHECKS
ATMOSPHERE & INERT GAS GENERATORS
ADSORPTIVE DRYERS • SINGEING EQUIPMENT

IBM Cuts Heat Treating Costs Eliminates Secondary Operations With Hevi Duty Shaker Hearth Furnaces

At **IBM's** Endicott Plant, one year's saving in labor and material amounted to approximately twice the original cost of this modern production tool.

Low Cost Raw Materials — now a less expensive carbon steel can be substituted for alloys which also means easier and faster machining and longer die life.

Clean Finish — cleaning costs are greatly reduced since only degreasing is required. An atmosphere protects the parts so they remain bright and scale free from the time they enter the furnace until they are withdrawn from the quench.

Labor Costs — the easy automatic operation of this furnace enables unskilled labor to increase production per man hour. Heavy manual labor is lessened. Fixing or stringing parts on wire is eliminated. Now, parts fed from a hopper, or placed onto the hearth plate, move through the heating zone and drop into the quench.

Improved Working Conditions — the clean, safe, and quiet operation of an electric furnace betters employee relations. The problem of cyanide waste disposal is eliminated.

These furnaces have paid for themselves while improving the mechanical properties of the product. Write for Bulletin HD-850 and the answers to your small parts heat treating problems.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

Welding Titanium . . .

taken into account in designing welded parts. The high-strength alloys are most attractive but lowered ductility after welding has hampered their widespread adoption. Heat treatments may restore a great deal of the properties but tests are not yet complete."

It should be noted that the author's conclusions apply only to the titanium alloy investigated in this program. Other alloy types (see "The ABC of Titanium Alloys", by W. L. Finlay, C. I. Bradford, and G. T. Fraser, *Metal Progress*, November 1952) may have quite different spot welding characteristics.

D. H. Luster

British Naval Gas Turbines*

In the last decade eight designs of gas turbines have been tested by the British Admiralty, ranging from a 275-lb. French engine for a portable pump weighing 0.78 lb. per rated max. hp. including all auxiliaries, to a 6500-hp. turbine to replace one set of steam machinery for main propulsion of a frigate and weighing 27.2 lb. per hp. The earliest (and apparently the most successful) were aircraft turbines installed in place of one of the three gas engines in patrol boats, to give high bursts of speed on emergencies. These had axial-flow compressors with anodized aluminum blades (to resist corrosion by salt air) driven by a single-stage turbine wheel (gas at 1475° F.). The 3-stage power turbine is on a separate shaft, and operates on the hot gases from the turbine driving the compressor. The ejector effect of the waste gas is then used to draw cooling air though a housing around the turbine. Ball and roller bearings on these (and other turbines) could not withstand the heat and the rapidly fluctuating loads during surging – the latter was severest at moderate or coasting speeds. Sleeve bearings may be more satisfactory. It is noted that weaving of the ship's hull in heavy weather

*Digest of "British Naval Gas Turbines", by G. F. A. Trewby, Institute of Marine Engineers, April 1954 Meeting, 25 p.

is also likely to throw severe loads on main bearings.

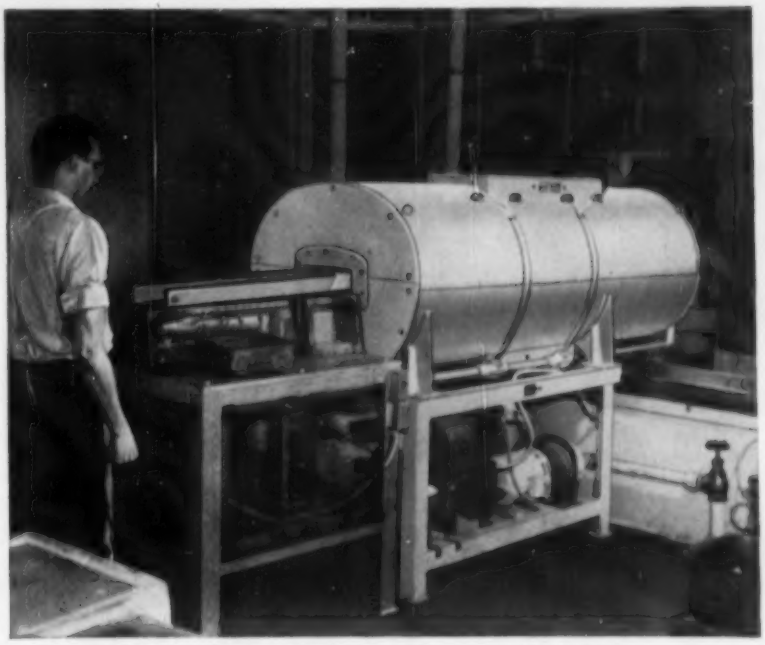
Commander Trewby remarks that "design life" is estimated for failure of disks and blades from creep at maximum temperature and stress, but since the percentage of time at maximum power is very low, the actual life of a critical part may be ten times the design life or even longer. Combustion chamber liners, bearings, seals and auxiliaries usually fail before disks and blades, and the overhaul periods are fixed by these auxiliaries.

A 5400-hp. main propulsion unit was made by Rolls Royce which weighed 5.3 lb. per hp., including auxiliaries. Two of them formed the power plant of a gun boat. Here again the bulk of the running time is for low-power cruising, and fuel economy at low speed required a high compression ratio in a triple compound compressor (158 psi. delivery) and three intercoolers or heat interchangers. Corrosion of the aluminum compressor blades has been severe, and (since weight is not a paramount consideration) these may be replaced with a metal more resistant to salt air. "Design life" of the hot parts (max. temperature 1520° F.) is 1000 hr., but again, operation at full throttle is so rare that 10,000 hr. may be expected.

Little is said about materials of construction. The small French turbine, extremely light and compact, could be adapted to suit naval requirements for emergency power "if British materials are used". The 200-hp. portable (600-lb.) turbine made by W. H. Allen Sons and Co., has a single rotating disk of heat resistant steel with air compressor valves on one face and turbine blades on the other face.

Commander Trewby says the greatest single advantage of the gas turbine for naval applications is "its ability to pack more power in less weight and space than any other prime mover". For example, the Rolls Royce power plant weighs 5.3 lb. per hp., whereas steam machinery for sister ships weighs 14 lb. per hp. Specific fuel consumption is also less at full power (0.66 lb. versus 0.88) and at cruising speeds (0.61 lb. versus 1.03). Gas turbines can operate satisfactorily on a wide range of distillates, including "Admiralty diesel", but at present the flame from "residual fuel" places a

IBM Improves Heat Treating Quality Cuts Costs With Hevi Duty Shaker Hearth Furnaces



At **IBM** — heat treated parts must meet rigid physical specifications and tolerances. Formerly a liquid cyaniding process was used and production was slow and costly. By using Hevi Duty Shaker Hearth Furnaces, the quality of the work has been improved and production has been increased.

The metallurgists at **IBM** state —

Controlled Case Depth — A uniform case depth of .002" to .015" is obtained. Three zones of temperature control assure an even temperature for the entire length of the hearth plate. The flexibility of dry cyaniding enables our operator to produce a case which is most suitable to the type of steel, shape, and function of the particular part.

Uniform Hardness — is obtained because all parts fall from the hearth into the quench individually. This is especially true of small studs which were formerly dumped from baskets into the quench.

Less Distortion — because in these furnaces the parts are not pushed or packed together. The work is heated and quenched at a rate which minimizes internal stresses and possible warpage. The warpage is less than that experienced with careful handling by former methods.

Clean Bright Surface — is a requirement because the work is flash chromium plated. Washing and cleaning time has been reduced.

The Hevi Duty Shaker Hearth Furnace is fully adjustable to give complete control of heat treating processes such as Hardening, Dry Cyaniding, and Carburizing. Write for Bulletin HD-850 which describes the furnace that assures uniform results on a production basis.

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

Increase ladle life

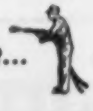
...with J-M 3X Blazecrete® the hydraulic setting refractory

You can make longer lasting linings for ladles with J-M 3X Blazecrete, because it is spall-resistant, withstands slagging action and has negligible shrinkage.

3X Blazecrete . . . the 3000F refractory . . . is easily and quickly applied . . . mix with water like ordinary concrete, and slap-trowel to desired thickness. Hardens without application of heat. Contains no harmful irritants . . . safe even for hand application. 3X Blazecrete is furnished as a dry mix, and may be stored indefinitely without deterioration.

You'll also find 3X Blazecrete ideally suited for forming run-out spouts and for gunning parts of iron cupolas.

Send for free brochure on Blazecrete (RC-28A) describing its properties and uses. To obtain your copy—as well as additional application details—write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 565 Lakeshore Road, Port Credit East, Ontario.

Whether you gun it...  *or slap-trowel it...*

JM PRODUCTS **Johns-Manville BLAZECRETE**

BUILDS BETTER REFRACTORY LININGS

Gas Turbines . . .

corrosive deposit on the turbine blades – a matter which, it is believed, can be corrected by improved combustion systems or by using certain additives with the fuel. Manufacturing costs also are about the same; simple cycle gas turbines and steam or diesel engines ordered to special requirements now cost about $42 per hp., and the author thinks that experience in construction will cut this in half, bringing cost down to that for turboprops for aircraft.

E. E. T.

Useful Microscopic Techniques*

SOME of the more important modifications in the metallurgical microscope which have been developed in recent years are described and evaluated in this article. The basic design of metallurgical microscopes and the best type of illuminating train remain unchanged, but plain glass slip formerly used as a vertical reflector has been improved by special upper and lower surface coatings. Efficiency is further increased by use of the Foster calcite prism reflector which is incorporated within the Bausch and Lomb Research Metallograph. The rotating stage is a useful introduction and is essential for polarized light work.

Phase-Contrast is used in metallography to aid in differentiating between two phases which are lacking in contrast and difficult to distinguish by other means. Variations in surface level on the order of 200 to 500 A (Angstrom units) are made readily apparent. (Surface differences of less than 50 A, and as little as a few Angstroms, have been revealed with this method.) It is accomplished by addition of an annular aperture and a special phase-plate to a microscope. Since phase-contrast establishes which portions of a specimen surface are higher than the remainder, it can be used for studying rates of attack in etching and for determining definitely whether dark

(Continued on p. 170)

*Digest of "Progress in Metallurgical Microscopy", by B. W. Mott, *Endeavor*, Vol. 12, July 1953, p. 154-161.

'Spill-Stop' Pourers *really* pour without spilling. When tipped into a glass the liquid flows up to the level at which the spout is held, but no farther. Then when raised, not a drop is spilled.

BALL OF CHROME DOME and Gold Dome Pourers is made of Formbrite Drawing Brass, either chromium-plated or gold-plated over bright nickel. Tubing is supplied by French Small Tube Branch, an Anaconda subsidiary. Cap and hinge material is furnished by Anaconda's Kenosha Branch.

"When it comes to finishing these 'Spill-Stop' Pourers, there's no comparison between Formbrite and ordinary drawing brass"

—says Spill-Stop Mfg. Co.

Spill-Stop* Manufacturing Company is enthusiastic in its praise for Formbrite*—Anaconda's new drawing brass.

They say, "We've used Formbrite for the ball of our Chrome Dome* and Gold Dome Pourers for two years. We save enough in *finishing costs* to sell our Pourers now at the same price we did in 1946 – despite increases in the cost of materials and labor."

Spill-Stop goes on to say, "We find Formbrite fabricates almost as readily as the softest draw brass . . . the close tolerance to which your mill has held the gage has contributed greatly to the ease of fabrication."

Yet Formbrite costs no more than the ordinary drawing brass Spill-Stop had been using. And Formbrite very often saves more than the metal itself costs.

WHY FORMBRITE CUTS FINISHING COSTS

Formbrite has a superfine grain. Special methods of rolling and annealing produce a grain structure so fine that often a simple color buff will bring it to a bright, lustrous finish.

Formbrite is also harder, stiffer, springier and more scratch-resistant . . . yet it is surprisingly ductile, readily stamped, formed, drawn and embossed. And Formbrite plates beautifully.

FREE SAMPLE

Formbrite is available in sheets, strips and coils – in all commercial widths and gages. Millions of pounds of this superior drawing brass have been made, sold and satisfactorily fabricated.

Want more proof? Send for a free sample of Formbrite. Try it in your polishing room. See for yourself how quickly and easily Formbrite polishes. Also ask for Publication B-39 which gives forming and finishing suggestions. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5401

*Reg. U. S. Pat. Off.

Formbrite
FINE-GRAIN DRAWING BRASS
an **ANACONDA**® product
MADE BY THE AMERICAN BRASS COMPANY

KENNAMETAL* BALLS

resist higher pressures

with less deformation than hardest steels

Kennametal has a Young's Modulus of Elasticity of 60 to 90 million psi—2½ to 3 times that of the hardest steel. Hence, deformation of Kennametal Balls is only ⅓ to ½ that of steel. They have much greater resistance to abrasion and withstand the corrosive attack of many reagents.

Kennametal Balls, fitted accurately into ground seats of the same metal, have been tested for over 15 years in severe oil well pump operations. Valving in hydraulic systems, parts for chemical processing and hardness testing are but a few of many uses for Kennametal Balls. They are available in several compositions of tungsten carbide, tungsten-titanium carbide, and tantalum carbide and cobalt, in many sizes.

Your idea for a revolutionary apparatus for high pressures and temperatures may be practical with Kennametal Balls and Seats. For more information, write for Bulletin C-53, KENNAMETAL INC., Latrobe, Pa.

3/16	3/8	½	11/16
$1.28	$2.86	$3.62	$5.70

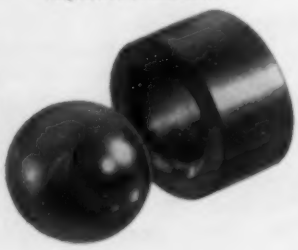
Prices per ball, when ordered in lots of 100 finished to ±.0002 inch. Prices for larger quantities upon request.

* Registered Trademark

INDUSTRY AND

KENNAMETAL

. . . Partners in Progress



Microscopy . . .

spots are pits or precipitate adhering to the surface.

The opaque-stop technique, accredited to Lomer and Pratt, is sufficiently sensitive to detect surface slopes equal to about 1′ at a magnification of 6×, and 1° at 200×. It involves use of an annular aperture combined with an annular stop, or a straight-edge stop may be used in conjunction with a point-source. Inclinations can be determined from the distance the stop must be traversed to eliminate light from each inclined face of the specimen. Pratt and Pugh used the opaque-stop technique for studying mechanisms of deformation in zinc showing complex twin movements not revealed by ordinary illumination.

The multiple-beam interference technique developed by Tolansky detects variations in surface level of about 25 A. Interference fringes are produced by a wedge-shaped air gap between a silvered, optically flat glass plate and the specimen. Tolansky recently described simple modifications for high magnifications using Canada balsam.

Dyson designed a unit to interpose between objective and specimen for resolving differences in levels of about 30 A. Light initially transmitted by the objective is divided at a half-silvered surface such that the part is focused on a small silver spot within the unit and part on the specimen. Interference occurs between the two resulting beams and is controlled by an axial movement of the glass plates.

Polarized light has been used extensively in metallography in recent years. Several publications give detailed accounts of applications.

Differences in orientation of anisotropic metal crystals of as little as 2° may be distinguished optically. It is especially useful for such metals as uranium, beryllium and zirconium where difficulty is experienced in revealing small differences of orientation by conventional etching methods. An outstanding feature is that, in polarized light, the surface may be viewed while still in the condition as polished. Cubic metals can be etched to give elliptically polarized reflected beams resulting either from a surface film which shows epitaxy

(Continued on p. 172)

Steel-Weld
FABRICATION
Use WELDED STEEL
for Greater Strength
with Less Weight!
Steel-Weld Fabricated parts and assemblies can save you time and money in many ways . . . they eliminate pattern costs and give you greater strength with less weight. The parts and assemblies shown at the left, and the forty-ton frame and carriage shown above—parts of a loading device for a large extrusion press—are typical examples of thousands of Steel-Weld Fabricated units produced and machined by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you need a special mechanical device, or if you require parts or assemblies involving large heavy pieces where time and pattern costs are a consideration, you can call on Mahon with complete confidence . . . personnel and facilities are available within the Mahon plant to handle the entire job from drawing board to finished machining and assembly. You will find in the Mahon organization a unique source . . . a source where design skill and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon engineer call at your convenience.
THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN
Engineers and Fabricators of Steel in Any Form for Any Purpose
MAHON

How about

FURNACE ROLLERS
HEAT TREATING TRAYS
FURNACE SHAFTS
ANNEALING BELTS
RETORTS
TUBING

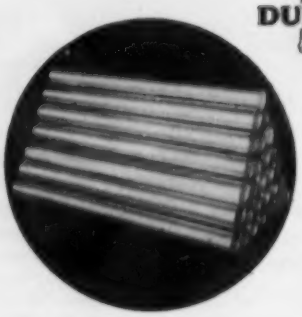
DURALOY

DURASPUN

Which are
Heat Resistant

Corrosion Resistant

Abrasion Resistant



When ready to order, how about checking with us here at DURALOY? For more than thirty years we have specialized in high-alloy castings. In fact, we were among the first to produce static castings and the first to produce centrifugal castings. We are old hands at producing castings alloyed to fit each specific requirement and to finish them to any extent desired.

Melt, castings and finishing are carefully controlled and quality tested by our staff of metallurgists, chemists, X-ray and gamma-ray technicians. If you would like more preliminary information, send for Bulletin No. 3150-G.

THE DURALOY COMPANY

Office and Plant Scottdale, Pa. · Eastern Office 12 East 41st Street, New York 17, N.Y.

Kansas City · New Orleans · St. Louis · Tulsa

Microscopy . . .

(oriented overgrowth), or from a regular array of pits. Polarized light aids in deformation and recrystallization studies, in measuring austenitic grain size in martensitic steel, and in distinguishing between phases which are optically anisotropic and those which are not. It is also employed for examining inclusions in ferrous and nonferrous metals and alloys.

Heated surfaces – Special apparatus is available for the examination of metal structures at high temperatures and during changes of temperature. For this purpose there are reflecting objectives of the Burch type using two spherical mirrors or the Dyson type using one spherical mirror and a silvered plane mirror.

H. P. Roth

Determining Amount of Nitrogen and Nitrides in Fe-C Alloys*

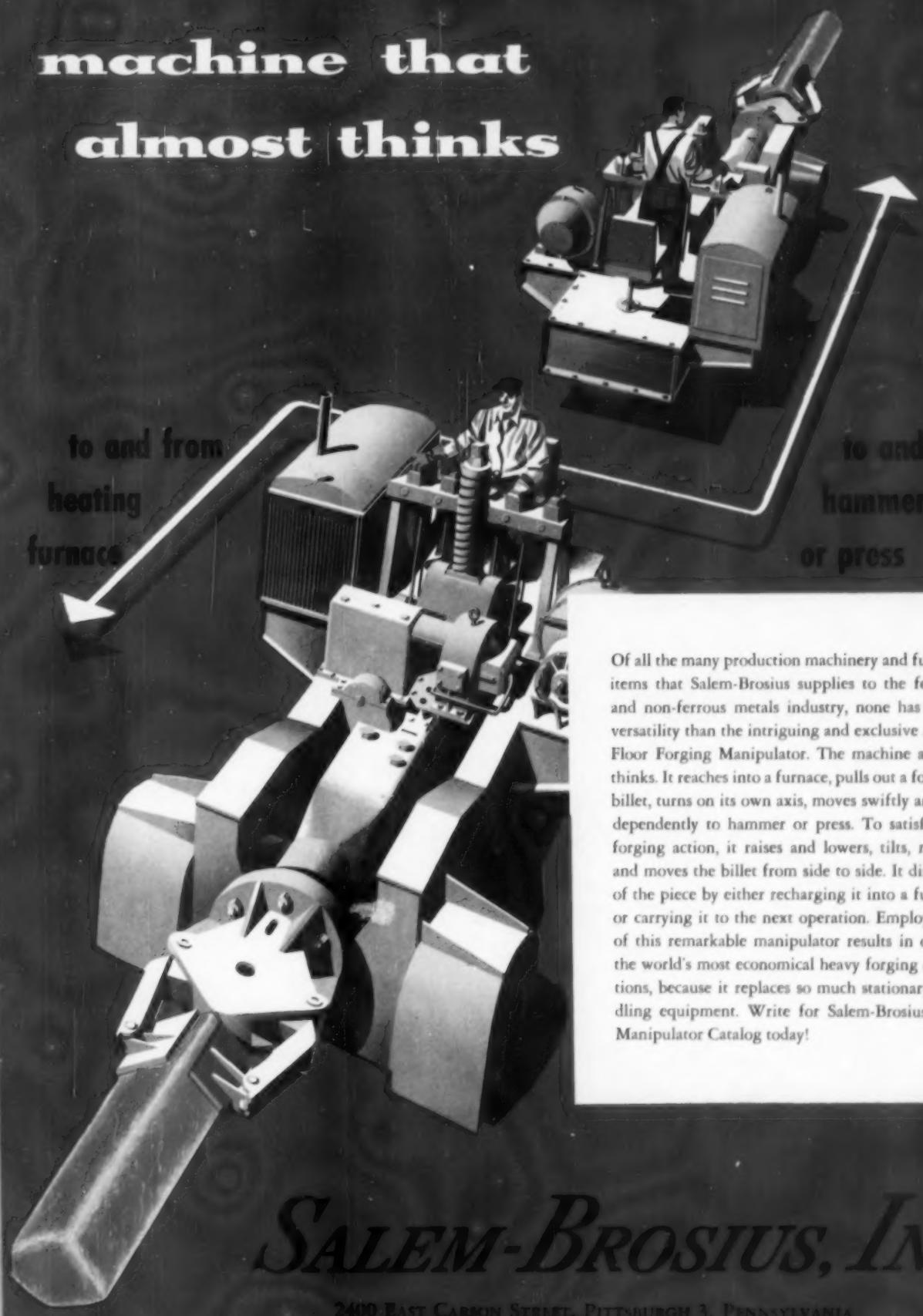
The increasing and often critical importance of the effects of small amounts of nitrogen on such physical properties as strain-aging, hardness, internal friction, elastic recovery and magnetic permeability of iron and steel is receiving greater attention among steel engineers. The steady decline of both acid and basic bottom-blown converter processes as production units in steelmaking and the recent strong interest in top-blown converters (turbo-hearth) and the new oxygen-blowing converter method indicate the importance of the nitrogen content upon the properties of steel and its aplications to modern fabrication practices.

The influence of various alloying additions to steel is bound up with the changes that they cause in the relative amounts of nitrogen in solid solution in iron and combined as a separate nitride phase. Many alloying elements are known to form nitrides more stable than those of iron, which enables the small amount of nitrides to be "fixed" as an insolu-

(Continued on p. 176)

*Digest of "Thermodynamics of Metal Nitrides and of Nitrogen in Iron and Steel", by J. Pearson and U. J. C. Ende, *Journal* of the Iron and Steel Institute, Vol. 175, September 1953, p. 52-58.

machine that almost thinks

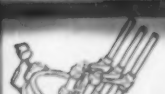


Of all the many production machinery and furnace items that Salem-Brosius supplies to the ferrous and non-ferrous metals industry, none has more versatility than the intriguing and exclusive Auto-Floor Forging Manipulator. The machine almost thinks. It reaches into a furnace, pulls out a forging billet, turns on its own axis, moves swiftly and independently to hammer or press. To satisfy any forging action, it raises and lowers, tilts, rotates and moves the billet from side to side. It disposes of the piece by either recharging it into a furnace or carrying it to the next operation. Employment of this remarkable manipulator results in one of the world's most economical heavy forging operations, because it replaces so much stationary handling equipment. Write for Salem-Brosius' new Manipulator Catalog today!

SALEM-BROSIUS, INC.

2400 East Carson Street, Pittsburgh 3, Pennsylvania

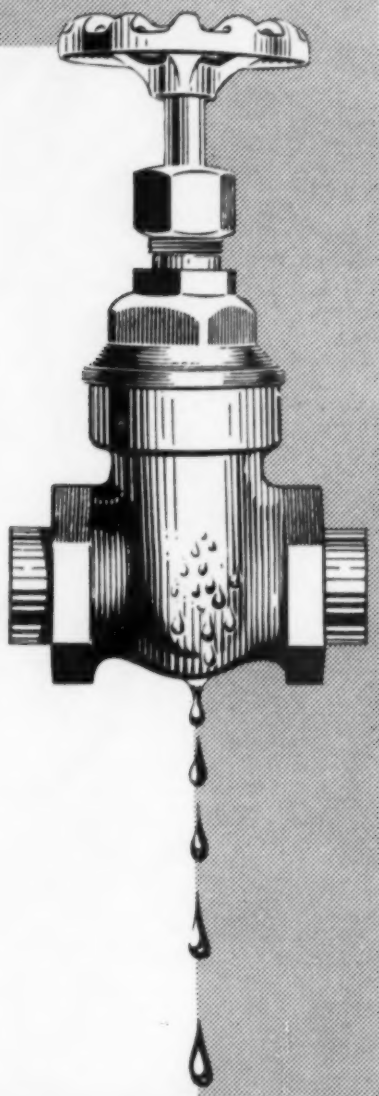
In Canada: Salem Engineering Ltd. · 1525 Bloor Street West, Toronto 9, Ontario



Tool Steel Twins

THERE IS A SOLUTION
TO YOUR NONFERROUS
Foundry Problems...

Melt Quality



When you call upon
LAVIN'S ENGINEERING SERVICE

MANY LEAKY CASTINGS RESULT FROM IMPROPER MELTING PRACTICES

When all other factors are entirely satisfactory in the production of a casting, low melt quality, resulting from improperly operated furnaces will yield leakers.

The absorption of gas by molten metal exposed to an improper furnace atmosphere will cause intro-connected microporosity, which is frequently the cause of pressure failure.

Regardless of the type of melting equipment employed, proper operation and the maintenance of suitable atmosphere is essential to the production of the high melt quality necessary for pressure tight castings.

Lavin's metallurgical staff is always ready to assist the foundryman in finding the solution of any routine or special casting problem. Our chemical and research laboratories are available to you at no cost or obligation.

Next time call upon LAVIN'S engineering service
"The Foundryman's Problems Are Our Problems"

FREE: Write for your copy of the 20-page Lavingot technical Journal Vol. 10 No. 1 & 2 Containing, Specifications . . . test bar designs Nonferrous Ingot & Casting Alloys in chart form.

RESEARCH — CONTROLLED REFINING
INSURE UNIFORM QUALITY

• REFINERS OF BRASS, BRONZE AND ALUMINUM • PRODUCERS OF ZINC BASE DIE CASTING ALLOYS • DEOXIDIZERS . . . DEGASIFIERS . . . FLUXES . . . SHOTS • CAST VIRGIN ELECTROLYTIC COPPER ANODES • TYPE METALS.

R. LAVIN & SONS, INC.

• OFFICES—Boston, Pittsburgh, Cincinnati, Minneapolis, Philadelphia, Cleveland and Detroit
• WAREHOUSES—Boston, Philadelphia, Pittsburgh, Cleveland, Detroit, Minneapolis and Houston

3426 S. KEDZIE AVENUE • CHICAGO 23, ILLINOIS
REPRESENTATIVES IN PRINCIPAL CITIES

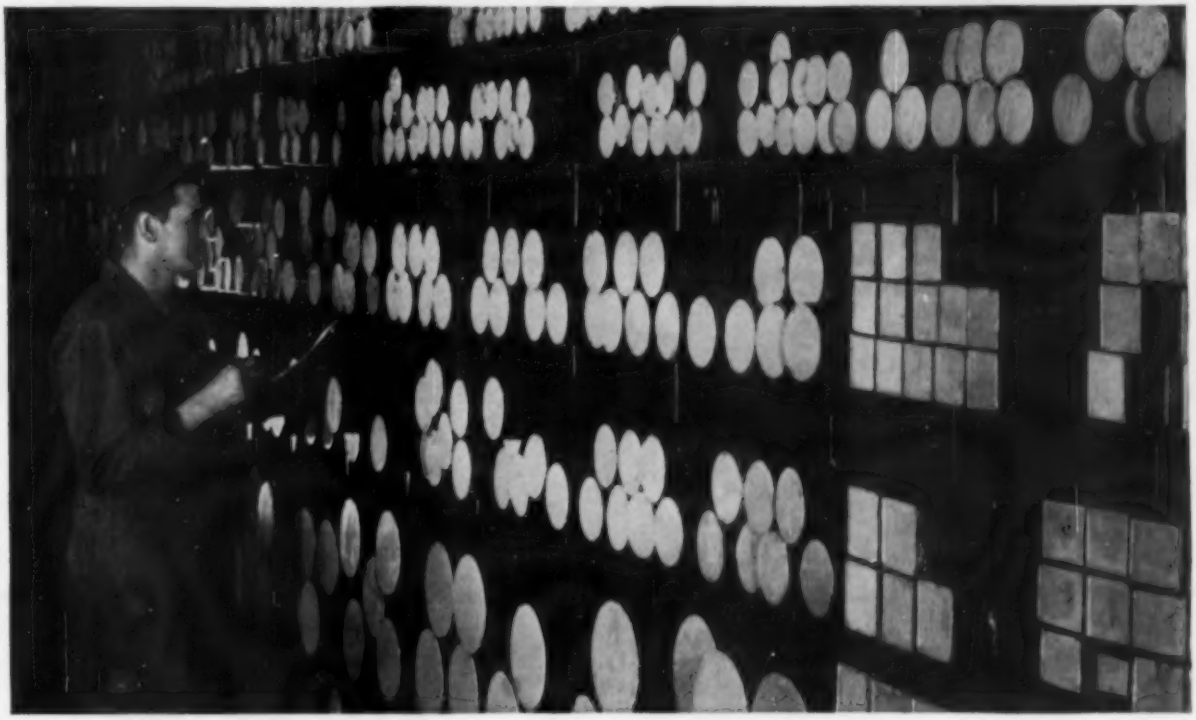
R. LAVIN & SONS, INC. 1900 *54 Years* 1954 SERVING THE FOUNDRY INDUSTRY

Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation



Want Fast Tool Steel Service?

SEE YOUR BETHLEHEM DISTRIBUTOR

Whether you want to order a short bar of tool steel, or merely wish advice about some phase of heat-treating, you're sure to find your Bethlehem tool steel distributor anxious to be of service.

For prompt service is your distributor's middle name. Why else does he make it a point to know your city like a book — its background, its people, its industry? He knows what kinds of steels you are most likely to need, and in what quantities. And so he keeps large stocks of Bethlehem tool steel on hand, in a variety of sizes and quantities, ready to go at a moment's notice.

If you want bars cut to special length, or if there's some tricky phase of metallurgy or any other tool steel problem troubling you, again your distributor is at your beck and call. He's a real friend.

66 HS and XX Team Up in Difficult Nut-Forming Application

The hexagonal punch and doming die, each quenched and drawn to a Rockwell C hardness of 61-63, are used in a cold-forming operation by a maker of nuts. The punch is made of 66 High-Speed. It is doing an outstanding job in holding close tolerances because of its excellent resistance to wear. The XX Carbon Steel die also provides good wear resistance, as well as resistance to shock, its high surface hardness and tough core enabling it to withstand repeated blows of the punch.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

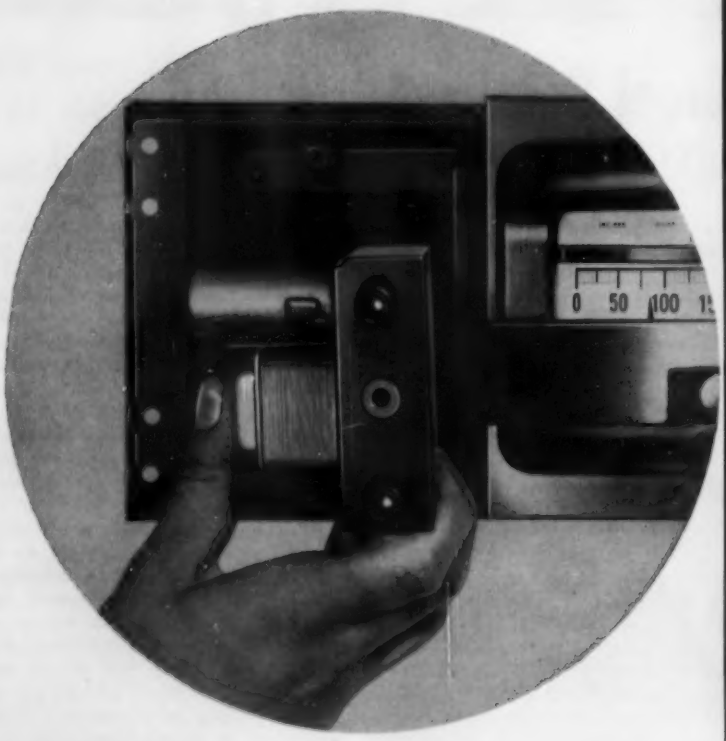
Scale is Tough Stuff

Whenever hot-rolled scaled stock is used in place of cold-rolled stock, the service life of the punches and dies drops to as much as a third of normal, largely because of the abrasion of the scaled hot-rolled surface on the cutting edges of the tools. The peculiarities of each situation determines whether or not such a substitution is economical.

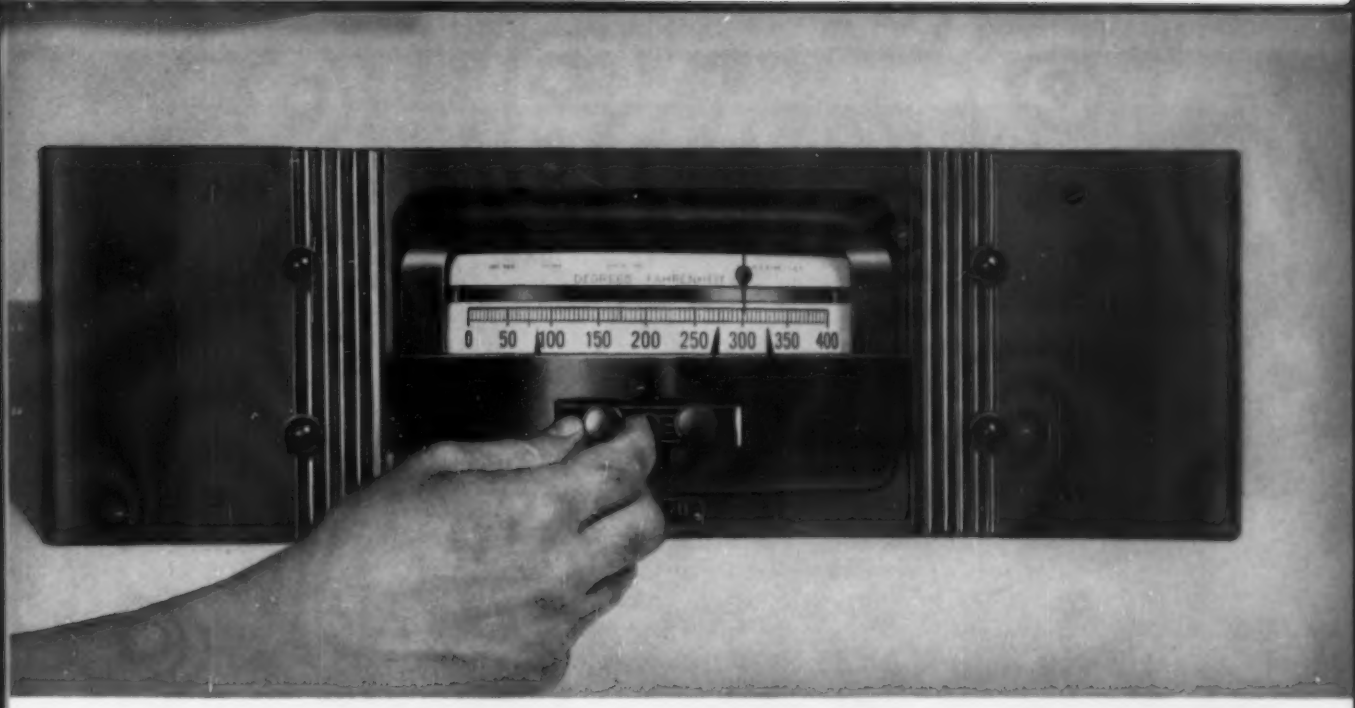
So the question is often asked: What can be done from the tooling end to avoid decreased production? If punches and dies are normally made from water-hardening carbon tool steel, or from manganese oil-hardening steel, decreased tool life can be avoided by changing to a high-carbon, high-chromium steel, such as Lehigh H or S. Such a change would largely overcome the disadvantage of hot-rolled scaled stock. But if high-carbon, high-chromium steels are already being used, effecting an appreciable improvement can be accomplished only through special heat-treatment, such as short-cycle hardening, or nitriding.

Brand new in performance... versatility... style...

the horizontal case



- ***New versatility of control—choose from***
  - —snap-acting on-off control
  - —pulse-type time-proportioning control
  - —three-zone control with dual indexes
- ***New ease of maintenance***
  - —plug-in galvanometer and control units
  - —thermocouple and millivoltmeter can be calibrated without disconnecting wiring
- ***New precision of measurement***
  - —virtually unaffected by ambient temperatures from 50 to 110 F.
- ***New ease of mounting***
  - —19″ wide case fits standard relay racks
- ***New convenience in operation***
  - —signal lights on control unit show high and low control position



Pyr-O-Vane® Controller

THERE'S more than a new look to this new *Pyr-O-Vane* millivoltmeter temperature controller. Its advanced performance and added features of versatility make it, more than ever, your top choice for economical, dependable control of ovens, furnaces, driers and scores of other kinds of heating equipment.

Its 19-inch wide horizontal case fits standard relay racks . . . permits stacking of controllers in smart-looking central panels. Plug-in unitized sub-assemblies reduce spot maintenance to seconds. Just replace the operating unit with a standby . . . and control continues with practically no interruption.

New refinements give the *Pyr-O-Vane* Controller greater precision and broader flexibility of control than ever before. Its sensitive electronic control can be applied to either fuel-fired or electrically-heated equipment. Your instrument men will appreciate its added ease of calibration and servicing . . . and your production men will like its dependability that stems from long-lasting, precision-made Brown components.

Whether you're modernizing your plant or modernizing the design of heat-using equipment that you manufacture, plan to take advantage of the new *Pyr-O-Vane* Controller . . . and its companion instrument, the new *Protect-O-Vane*® excess temperature safety cut-off. Your local Honeywell sales engineer will be glad to consult on your specific application . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA:** Write for new Bulletin 1080, "Horizontal Case Millivoltmeter Controllers."

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

H HONEYWELL

First in Controls

All ABRASIVES Have Faults!

Conventional chilled iron abrasives break down rapidly, cause high maintenance costs ; annealed iron abrasives don't have the cutting efficiency, tend to leave graphite deposits . The choice is determined by the side of the abrasive fence you are on ; your own blastcleaning requirements are the deciding factor. But here's a point: Controlled T "chilled" and Permabrasive "annealed" shot and grit are engineered to overcome the respective disadvantages of chilled iron and annealed iron abrasives. If you must use chilled iron abrasives, Controlled "T" cleans as fast as any chilled iron abrasive , yet lasts far longer, is easier on equipment. If you can use annealed iron abrasives, Permabrasive cleans fast, leaves a *clean* surface and is the most durable of all annealed iron abrasives. We'll guarantee a savings* in writing , and give you a check to produce the guaranteed savings if we fail.

*10% in the case of Permabrasive
15% in the case of Controlled T

produced by

THE NATIONAL METAL ABRASIVE COMPANY
Cleveland, Ohio

THE WESTERN METAL ABRASIVES COMPANY
Chicago Heights, Illinois

SOLD EXCLUSIVELY BY

HICKMAN, WILLIAMS & COMPANY

(INCORPORATED)

CHICAGO • DETROIT • CINCINNATI • ST. LOUIS • NEW YORK
CLEVELAND • PHILADELPHIA • PITTSBURGH • INDIANAPOLIS

Nitrogen . . .

ble constituent in the steel, thus depressing many of the detrimental effects of nitrogen.

The authors of this paper have collected the available equilibrium and thermal data on many of the nitrides and have used the information to calculate equations for the free energy of formation. The derived equations are presented in the form of diagrams for nitrogen potential versus temperature. These should be very useful to steel men for rapid and approximate calculations of the value of alloy additions. As is to be expected, the interpretation of these diagrams is subject to several restrictions and limitations before they can be applied to particular conditions.

Standard States — The standard state adopted for gases is that of a pure substance at 1 atmosphere of pressure. Due to the nonstoichiometry of the nitrides and to the solubility of nitrogen in the metals, the standard states for nitrides depend upon the method by which the results have been obtained. When free-energy changes are calculated from thermal data only, the standard state of the nitride is that of the pure material with a nitrogen content generally at the upper limit of the homogeneity range; the standard state of the metal is that of a pure solid or liquid. Where the free-energy change is calculated from equilibrium results, the standard state of the nitride is that of the compound at the lower limit of the homogeneity range and that of the metal as a nitrogen-saturated solid solution.

Nonstoichiometry of the Nitrides — Metallic nitrides have a marked tendency to be nonstoichiometric. Their homogeneity may be low, as with ferric iron and nitrogen, or high, as with titanium nitride or zirconium nitride. The homogeneity limits may vary with temperature; little information is available on the energy relationships within these ranges. Comparison of equilibrium and calorimetric data is difficult when a nitride is in equilibrium with its parent metal or with a lower nitride; then its composition will be at the lower limit of the homogeneity range. Thermal data, on the other hand, are usually reported for materials that are made by submitting the metal to

(Continued on p. 178)

What's Behind This Cutting Oil Picture?

Behind this cutting oil picture there's a story well worth telling . . . a story of 10 years' operation of the M. O. Devers Screw Machine Products Company.

During this time Devers has acquired and maintained a reputation for turning out the very highest quality precision machined parts and turning them out on time.

And during this same period, the oil that has helped Devers to achieve this enviable record is Cities Service Chillo #10 Cutting Oil. This one unusual oil has been used for work covering 1018, 1020, 4140, and stainless steel, and, says Devers official Harry E. McDaniel, "We have found it superior for all these machining operations."

For longer tool life, closer tolerances, and a simpler cutting operation, you—like the M. O. Devers Company—will find it profitable to investigate Cities Service Chillo Cutting Oils. Contact your nearest Cities Service representative or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N.Y.

CITIES SERVICE

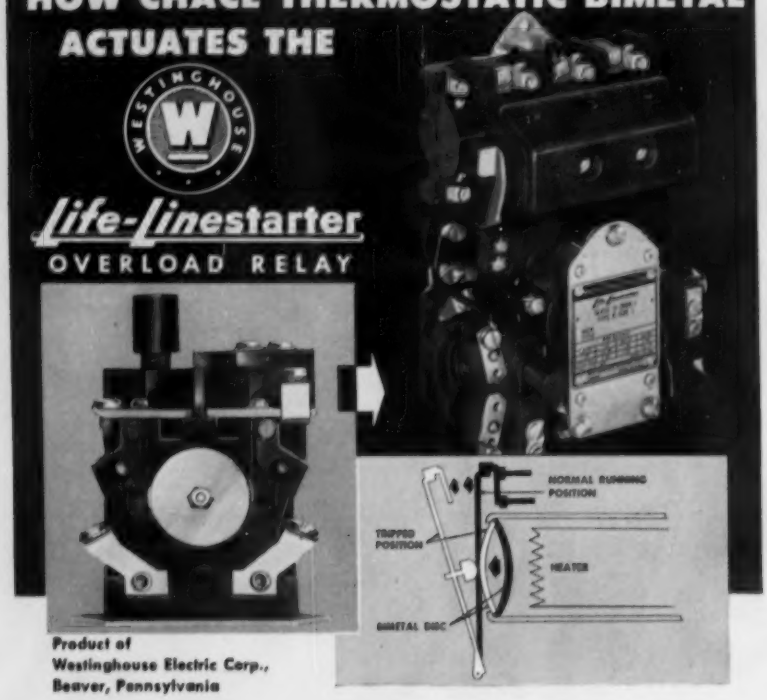
QUALITY PETROLEUM PRODUCTS

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE

WESTINGHOUSE

Life-Linestarter

OVERLOAD RELAY



Product of
Westinghouse Electric Corp.,
Beaver, Pennsylvania

The Westinghouse Life-Linestarter provides positive protection against dangerous overload and motor burnout. This overload protection is accomplished by means of Chace Thermostatic Bimetal in the form of a snap-action, disc type of overload relay. This is a precision device, more reliable than conventional solder pot type relays since the bimetal disc retains its precise calibration over years of operation and is not affected by oxidation.

HOW IT WORKS

The overload relay is furnished set for hand reset operation. The relay may be set for automatic reset, hand reset or hand reset with no manual means of opening the contacts.

Under overload, the temperature of the heater element adjacent to the Chace Thermostatic Bimetal disc increases. When the temperature rise attains a predetermined level, it causes the bimetal disc to deflect from a normally concave to a convex position. The impact of the disc against the moving contact arm forces the contacts to open and break the coil circuit, opening the starter contacts and stopping the motor. When the bimetal disc cools, it snaps back to its normally concave position. After the cause of the overload has been eliminated, the relay is easily reset and the motor again started. The bimetal disc cannot be damaged by attempted reset at any time during its cooling period.

Chace Thermostatic Bimetal is available in 29 different alloy combinations, in strip, coil or in complete elements, fabricated to customer specification. Send for our new, free booklet, "Successful Applications of Chace Thermostatic Bimetal," containing valuable engineering information for designers of thermally responsive devices.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1626 BEARD AVE., DETROIT 9, MICH.

Nitrogen . . .

atmospheres of high nitrogen potential and which may have a composition within the homogeneity range.

Solubility of Nitrogen in Metals — Metals also dissolve appreciable amounts of nitrogen in addition to forming nitrides and thus the equilibrium exists between the stable nitride and the parent metal saturated with dissolved nitrogen. Unless the free energy and solubility relationships of the solutions are known, it is not possible to apply accurately the equations calculated from calorimetric experiments to equilibrium systems. These three factors must be recognized when using the free-energy equations given in the appendix of the paper.

Using published data of heats of formation, heat capacities and the results of equilibrium studies, a standard free-energy diagram for the formation of metal nitrides covering a temperature range from 0 to 2000° C. (32 to 3630° F.) is presented in the paper. An appendix gives the free-energy equation used in the chart for each of the metal nitrides discussed.

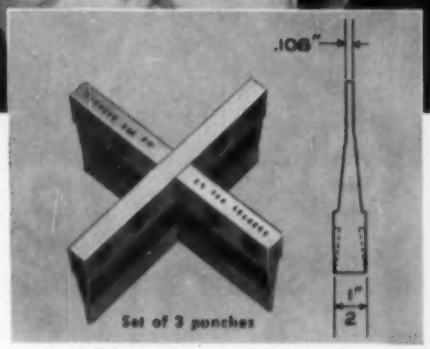
Based on the free-energy diagram of the metallic nitrides, the authors discuss the equilibrium, the percentage of alloy in steel, nitrogen and the free phase of alloy nitride, assuming that the alloying elements behave ideally. A second chart gives a method for calculating the dissolved nitrogen in alloy steels. The authors admit that this chart is only qualitative since the ideal behavior is not logical for silicon, aluminum, titanium and zirconium, nor is the assumption that the alloying elements do not affect the activity coefficient of the dissolved nitrogen.

The use of this second chart for calculating the dissolved nitrogen content in the presence of a nitride-forming element in steel is illustrated by using vanadium, which is well known to stabilize mild steel against strain-aging. In spite of the questionable assumptions made, the calculations agree fairly well with past experience and indicate that:

1. If the vanadium content is in excess of that stoichiometrically equivalent to the nitrogen content, the material will contain no free nitrogen at low temperatures. Ma-

(Continued on p. 180)

How One Toolroom Superintendent Used This Chart



Job: A set of three special punches used on a high speed machine to close the joints on prefabricated metal window frames made from ⅛" thick SAE 1010 steel.

Problem: Many types and grades of tool steels were tried, but all lacked the necessary toughness and hardening safety. Best service life from any before breakage was three days. Because a set of 3 punches cost hundreds of dollars to make, the low production was hiking up operating costs at a prohibitive rate.

Solution: In a final effort to find a steel with enough toughness and safety in hardening, the Toolroom Superintendent turned to Carpenter and the Matched Set Method. Carpenter R.D.S. (Oil-Tough) was indicated.

Results: Now punches stay in service for about three months, and instead of breaking, they wear out in service.

. . . To Hold Down Operating Costs

In working with many men responsible for tools and dies, we've discovered a simple but often overlooked fact: The man who approaches each tool and diemaking job with the idea of . . . *Simplifying* it, *Reducing* heat treating hazards, and *Improving* previous performance . . . is bound to do a better job.

If you or your men have that approach, Carpenter wants to be of help. We like to think of our association with customers as a "partnership" in a mutual effort to get best possible results. And here's what we offer: Practical, *workable* help at *every step* from diemaking, to heat treating, through on-the-job performance.

And that's why it works . . . both of us have a common goal. Just one example of hundreds is found in the Field Report shown to the left.

One part of this program is the Carpenter Matched Set Method. It is an accurate blueprint for selecting the *one* die steel ideally suited to give you the results you want. It is all outlined in a convenient, full-color Wall Chart available to you.

And that's only a part of the program . . . a program that involves almost 70 years' experience in the development of new and constantly-improved die steels. We're ready to work for you, now. Simply call your nearest Carpenter Mill-Branch Warehouse, Office or Distributor. THE CARPENTER STEEL CO., 133 W. Bern St., Reading, Pa.

Carpenter STEEL — Matched Tool and Die Steels

IMMEDIATE DELIVERY from local warehouse stocks

Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

YESTERDAY
TODAY
TOMORROW

CONTINENTAL

Serves Industry Everywhere

COMPLETE PLANTS designed, constructed, and equipped as an integrated unit for efficient and economical production.

CONTINENTAL

Tomorrow's Designs Today

SPECIAL EQUIPMENT industrial furnaces, ovens, gas generators, and dryers—all fuels—field or shop erected.

PRODUCTION LINES tailored to individual needs requiring minimum labor for maximum output.

CONTINENTAL

30 Years' Extensive Experience

insures prompt service in planning and production by experienced engineers who know industry's problems. Our numerous sales and service centers keep in constant touch throughout all phases of the work.

Write for Booklet No. 135

This booklet covers the scope of CONTINENTAL Service. It is well illustrated with views of CONTINENTAL installations with descriptions of the equipment and the processes performed.

5242

CONTINENTAL INDUSTRIAL ENGINEERS, INC.

176 W. Adams Street, Chicago 3, Illinois

DISTRICT REPRESENTATIVES

Ridgewood, N. J. • Indianapolis • St. Louis • Detroit
Cincinnati • Milwaukee • Cleveland • Pittsburgh

Nitrogen . . .

terial annealed below 700° C. (1290° F.) should therefore have all nitrogen combined as nitride and not be susceptible to strain-aging.

2. The annealing temperature at which free or dissolved nitrogen begins to be significant increases as the residual vanadium increases, for a given nitrogen content, and decreases as the total nitrogen content increases, for a given vanadium content. Material annealed above this temperature is therefore liable to strain-aging, for it is unlikely that all the free nitrogen will combine with excess vanadium. An example of these calculations for a steel containing 0.006% nitrogen indicates no dissolved nitrogen below 500° C. (930° F.) when the vanadium content exceeds 0.022%, only 0.0002% dissolved nitrogen up to 750° C. (1380° F.) when the total vanadium is above 0.030%. Above 1380° F. the amount of dissolved nitrogen increases to almost complete solubility at any vanadium content.

An extensive appendix and bibliography are also included in this valuable paper.

E. C. WRIGHT

Creep Tests of Smooth and Notched Specimens*

THE TITLE of this paper seems rather restricted for the broad scope of an appraisal which covers the entire field of creep tests on smooth and notched specimens. Some parts of the report are difficult to follow because of the absence of a full explanation for many of the graphs, as well as a few peculiarities in the wording of the text which seem most likely to be due to typographical errors.

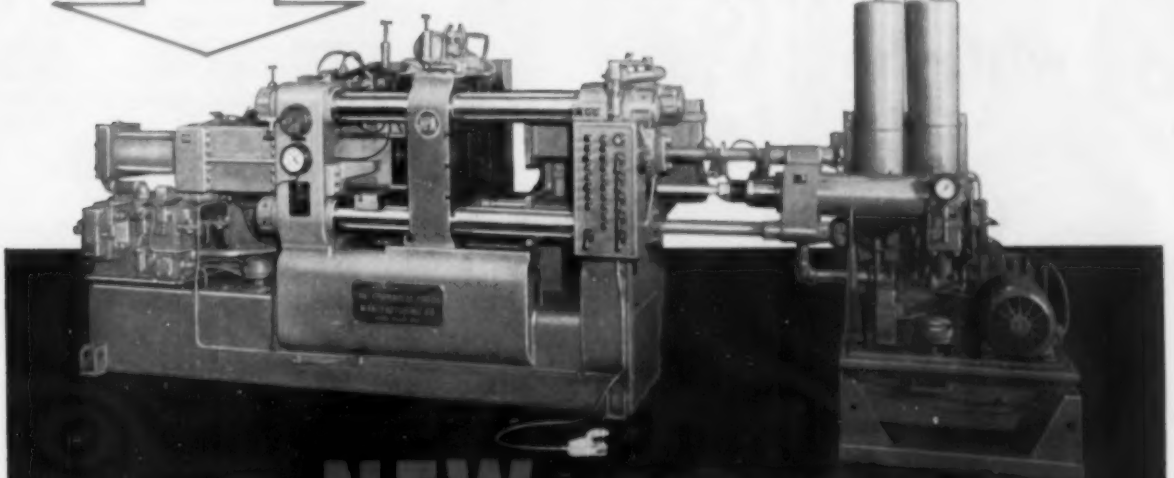
The paper is based on an apparently enormous number of tensile, creep, metallographic and X-ray

(Continued on p. 182)

* Digest of "Investigations into the Development of Intercrystalline Fractures in Various Steels Under Triaxial Stress", by W. Siegfried, Paper No. 16 of the Symposium on Creep and Fracture of Metals at High Temperatures (National Physical Laboratories), May-June 1954.

ALL NEW SELF-CONTAINED CLAMP END

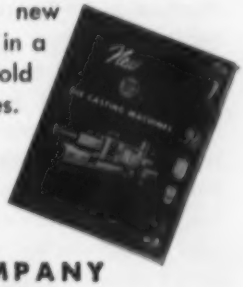
ALL NEW SELF-CONTAINED INJECTION END



A NEW APPROACH TO DIE CASTING

New H-P-M Die Casting Machine offers more than just New Machine Design

The new H-P-M die casting machines are being hailed as the most important advancement in die casting in fifteen years, and rightly so . . . more than forty new and improved features! These features result in minimum mold flash . . . faster die set-up . . . greater versatility in die usage and casting design... reduced maintenance . . . maximum safety and performance. The new self-contained Link-Wedge mold clamp is the best. There's plenty of "beef" in these new models. They are available in a complete range of sizes... cold chamber or gooseneck types.



Write for Bulletin 5400 which describes these new units in detail.

HPM

THE HYDRAULIC PRESS MFG. COMPANY
3020 Marion Road, Mount Gilead, Ohio, U. S. A.

Take surface temperatures quickly, accurately... with the

Pyrocon

The handy Alnor Pyrocon is unequaled for quick, accurate reading of all surface temperatures . . . whether they are metallic or non-metallic, flat or curved, stationary or revolving. Accurate temperatures are easily understood on the Pyrocon's direct reading scale face . . . without interpolation or need of conversion tables. A wide selection of thermocouples and extension arms permits adaptation to many types of service. For complete details and prices, send for Bulletin No. 4257. Illinois Testing Laboratories Inc., Room 523, 420 N. LaSalle Street, Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Creep Tests . . .

tests carried out at the plant of Sulzer Brothers, Ltd., Switzerland, on heat resisting steels containing 7 to 75% nickel and 13 to 20% chromium, as well as on a 94% tin, 6% cadmium alloy. The main objective was to find an explanation for the failures caused by notches in parts made from such steels while in service at high temperatures. The effects of cold work, precipitation and recrystallization temperatures are also discussed.

Notched specimens of the very ductile tin alloy were stronger in creep than smooth specimens and illustrated how creep can change the form of a notch. Notched specimens of cold worked steels have lower creep strength than those of steels not cold worked, if the austenitic structure is not stable. Some of the steels tested showed higher creep strength for notched specimens, for some the notch made no difference, while a very brittle steel was weakened in creep by a notch.

Incipient cracks in creep test specimens were examined metallographically. Widely distributed internal cracks are caused by the formation of sigma at grain boundaries of steels having unstable structure, and in such steels the presence of a surface notch makes little difference in the progress of creep. If the grains have a high capacity for deformation, the stress concentration at an incipient crack may be relieved so that an intercrystalline fracture does not develop.

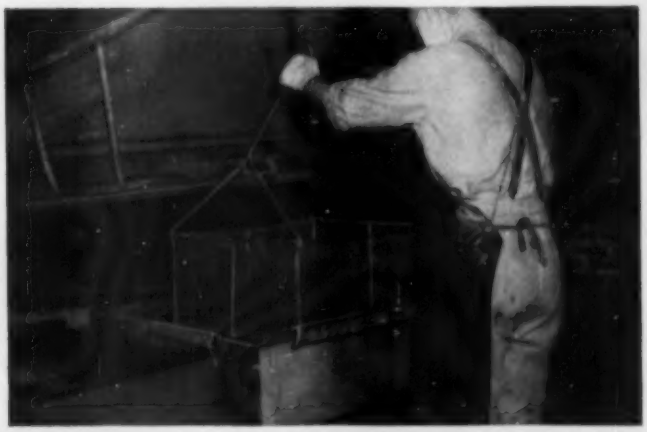
The effect of recrystallization temperature on embrittlement was investigated by X-ray diffraction. This temperature is raised more by molybdenum and tungsten additions to steel than by other alloys. An increase in this temperature raises the strength of both the grains and the grain boundaries. Precipitation, on the other hand, strengthens the grains without benefit to the boundaries. Specific examples are cited of different combinations of these characteristics. A steel with high capacity of the grains for deformation but weak grain boundaries is susceptible to intercrystalline cracking in creep.

Cold working a steel of poor structural stability may promote subsequent formation of sigma at the

(Continued on p. 186)

Why Pickle the Equipment Too?

ALLOY TRAYS SAVE $1600 A YEAR—Pickling trays made of HASTELLOY alloy C have saved a company $1600 a year. The trays are immersed in hot 20 per cent hydrochloric acid and then into a solution of one per cent phosphoric acid with ferric salts at 205 deg. F. This treatment is used to produce a porous surface on metal parts. HASTELLOY alloy trays last two years. Other trays lasted only two months.



SIX YEARS IN HOT HCl—This HASTELLOY alloy B pickling tank has already outlasted other materials by four times. It is expected to be good for many years to come. The tank holds hot 15 per cent hydrochloric acid used to remove grease and lacquer from cast iron parts.

VAT PAYS FOR ITSELF—Here's a HASTELLOY alloy C vat that has already paid for itself and is still going strong. It is used to pickle copper parts in a mixture of 30 per cent nitric acid and 60 per cent sulphuric acid at 180 to 200 deg. F. Crocks previously used had to be replaced on an average of every six months.

•

HASTELLOY *alloys can solve some of your corrosion problems, too. For further information, contact the nearest Haynes Stellite Company office listed below.*

"Hastelloy" is a registered trade-mark of Union Carbide and Carbon Corporation.

HASTELLOY *alloys*
Trade-Mark

Nickel-base, corrosion-resistant alloys available as sheet, plate, bar stock, welding rod, welded tubing and pipe, cast pipe and fittings, sand and precision-investment castings.

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

Metals Engineering

at Leeds & Northrup

as described by A. E. Tarr,

Industrial Sales Manager,
Leeds & Northrup Company

"The importance of metals engineering decisions on our product designs, material specifications and production procedures cannot be overestimated.

"For example, our Metals Engineers direct the design and application of all metal products, decide on materials and help select suppliers. They work with aluminum, copper, steel, nickel, Manganin, Mumetal and the thermocouple alloys . . . choosing the metal best suited for each specific component.

"Selection of the various heat treating methods and equipment is a problem for our Metals Engineers, as are the forming, finishing and fabricating decisions that must be made.

"Sales work too is constantly involved with metals engineering. Customers rely on our recommendations based on knowledge of their instrument and control problems . . . with selection of metals as a prime factor. They depend on our Metals Engineers—who read *Metal Progress*—and who are largely responsible for performance of our products wherever used."

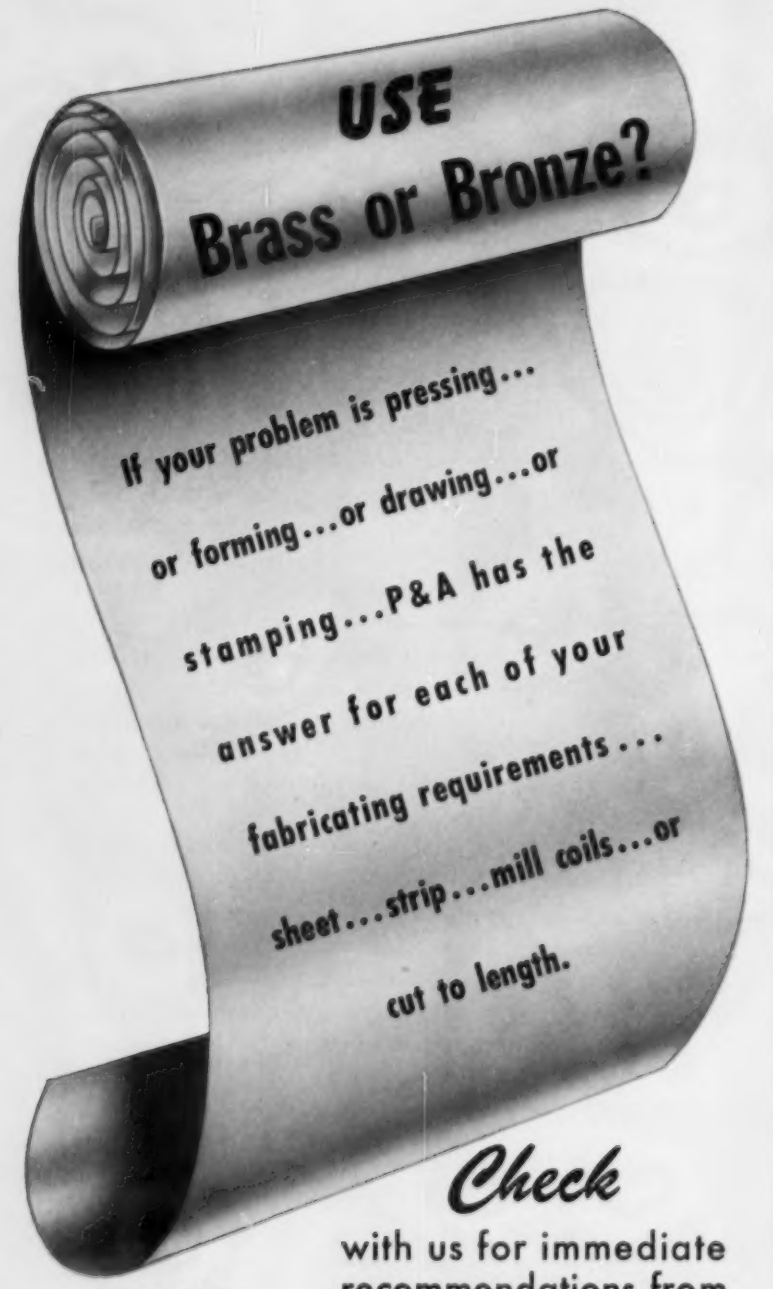
Magazine of 26,000
Metals Engineers

Metal Progress

A publication of the American Society for Metals
Originator and sponsor of the National Metal Exposition

7301 Euclid Avenue, Cleveland 3, Ohio

These new Leeds & Northrup Speedomax Type "H" Recording Controllers can provide on-off or proportional control for many processes. Examining them are A. E. Tarr, Industrial Sales Manager; D. I. Finch, Chief, Metallurgical Division; J. F. Quereau, Production Manager; and J. W. Harsch, Director of Engineering . . . all members of the American Society for Metals and readers of *Metal Progress*.



Check
with us for immediate recommendations from your samples or specifications...

WATCH FOR OUR ANNOUNCEMENT
We are moving to our new, Modern Plant in Thomaston ... Soon!

P&A
ESTABLISHED 1868

THE PLUME & ATWOOD MFG. CO.
Main Office and Fabricating Div.: 530 Bank St., Waterbury, Conn.
Mill Div.: Thomaston, Conn. N. Y. Office: 220 Broadway

Creep Tests . . .

grain boundaries during creep, so that the strength is materially impaired as compared with the same steel when not cold worked before creep testing.

Annealing tests established that a marked acceleration of precipitation may result from stress at high temperature as in a creep test. If precipitation is sufficient to cause embrittlement, a lower stress may result in a shorter time to fracture of a notched specimen.

In creep tests at constant load the stress increases as deformation occurs, and the strength of the specimen decreases due to the effects of temperature and time, and these complicated conditions have led to discrepancies of opinion on the evaluation of the tests. The interrelations of the cohesive strength curves for different types of specimen with the typical time-stress creep curve are exhibited in a number of charts and discussed at considerable length. An alloy of low cohesive strength may fail by intercrystalline rupture before the third stage of creep is reached. Notches causing stress concentrations and triaxial interior stresses increase the length of the time-strain curve, and whether a notched bar fails early in creep depends on the relative rate of change of the cohesive strength. The effect of a notch may be different when different stresses are used in creep testing. Precipitation decreases the cohesive strength, but the amount of the reduction depends on the test stress. These complicated relations between precipitation, stress, and embrittlement are illustrated graphically.

Maximum stress concentration in an elastic material occurs with a ratio of notch diameter to specimen diameter equal to about 0.6, but in creep when the material is not elastic this cannot be calculated. Results of creep tests with specimens of an alloy having high cohesive strength and varying notch depths indicated an increase in the time-to-fracture with a notch of medium depth, and an approach to the values for a smooth specimen at very small and very great notch depths. If the alloy has low cohesive strength, the time-to-fracture may

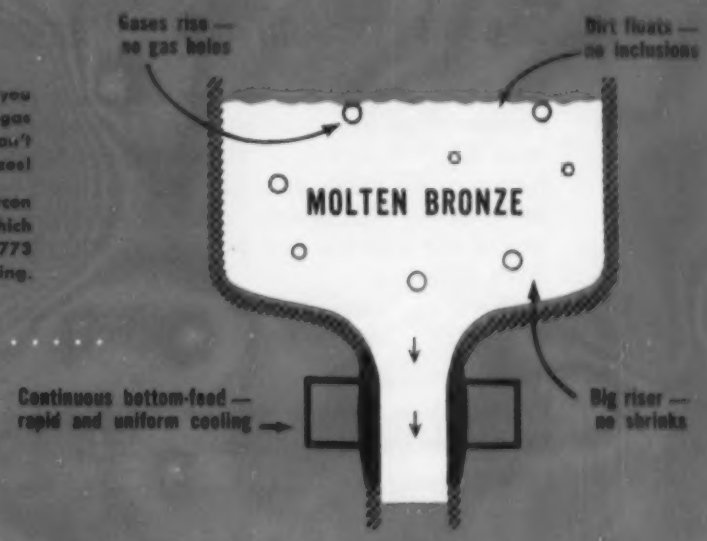
(Continued on p. 188)

Save on Bearing Bronzes . . . Asarco's Continuous-Cast Quality and Sizes Conserve Metal and Machine-Shop Time

You lose metal . . . you lose time . . . you ruin tools . . . when machining uncovers gas holes, shrinks, dirt, inferior metal. But it can't happen with Asarco 773 (SAE 660) bronzes!

The sketch shows how the patented Asarco process eliminates the metal defects which gnaw at machine-shop profits. Asarco 773 assures sound castings, profitable machining.

HERE'S WHY . . . . . .


Gases rise — no gas holes
Dirt floats — no inclusions
MOLTEN BRONZE
Continuous bottom-feed — rapid and uniform cooling
Big riser — no shrinks

Save on Lengths: Your distributor gives you exactly the length you want from 0 to 105". You buy less metal. There is no short-end scrap loss.

Save on Diameters: Clean-up allowances on Asarcon bronzes, both inside and out, are only a quarter those of rough-cast bars. You take less out of tools, reduce machining time; and again, buy less metal.

Save on Physical Properties: Quality of metal increases service life of bearings or other parts made of Asarcon 773 . . . cuts downtime.

Buy standard Asarcon 773 bronze (SAE 660) up to 105" long in 216 sizes of round solids and tubes from distributors throughout the country . . . or order special alloys and shapes in any length you want. Mail coupon below for new illustrated bulletin on Asarcon 773.

ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES

AMERICAN SMELTING AND REFINING COMPANY
Perth Amboy Plant, Barber, N. J. • Whiting, Ind.
West Coast Sales Agent
Kingwell Bros. Ltd., 457 Minna St., San Francisco
In Canada
Federated Metals, Canada, Ltd., Toronto and Montreal

AMERICAN SMELTING AND REFINING COMPANY
Perth Amboy Plant, Barber, New Jersey

- ☐ Please send new brochure on Asarcon 773 stock bearing bronze
- ☐ Send literature on other Continuous-Cast Bronzes
- ☐ Send a salesman

Name . . . . . Title . . . . .

Company . . . . .

Address . . . . .

City . . . . . Zone . . . . State . . . . .

How To Cut Costs in Metal Treating!

...Use BARRETT BRAND • Anhydrous Ammonia

–and you have the most economical source of dissociated hydrogen and nitrogen for metallurgical uses. 6,750 cubic feet of Hydrogen and Nitrogen from a single 150 lb. cylinder! And you don't have to stock up heavily–our coast-to-coast delivery service will give you *fast* delivery on 150, 100 and 50-lb. cylinders.

Check the many jobs Barrett Ammonia can do so well–then order today!

Do You Use Anhydrous Ammonia for *These* Important Jobs?

- Protective atmosphere for bright annealing, brazing and powder metallurgy.
- Nitriding of alloy steels and carbonitriding (Dry Cyaniding) for treatment of steel.
- Case hardening of iron and steel with case depths up to 0.025 inches.
- Sintering of metal powder compacts.
- Augmenting corrosion–resistance treating for aluminum, magnesium, other light metals.
- As a solvent in making electrolytes for electrolytic recovery of salts.

GET THIS VALUABLE HELP!

Technicians specially trained in the use of Anhydrous Ammonia for the above and other metallurgical uses are ready to help you. No obligation. Call or write today! Also–valuable handbook available on the use and economical handling of Ammonia. Request it.

Look for the green cap!

First in Ammonia Since 1890

NITROGEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 Rector Street, New York 6, N. Y.

Hopewell, Va. • Ironton, Ohio • Orange, Tex. • Omaha, Neb.

Creep Tests . . .

vary in the opposite way with change in notch depth.

An explanation is arrived at graphically for the observation that cracking in creep is often found at a distance from a notch, and not at the notch root. Thus the cracks may not be due primarily to triaxial stress conditions, as has been concluded from other experiments.

The conclusion is that all the phenomena observed in high-temperature creep tests can be explained if constant material properties are not assumed, but time-dependent functions are involved which vary with the nature of the material and with the stress conditions.

G. F. Comstock

Hydrogen in Iron-Carbon Alloys*

Although the solubility of hydrogen in relatively pure iron and in several iron alloys has been the subject of some careful studies since Sieverts' work at the turn of the century, the precise behavior of the gas in iron-carbon alloys has remained a subject of dispute. The present study was undertaken by the Joint Cases Subcommittee of the Institute of British Foundrymen and the British Cast Iron Research Association. The carbon content of the specimens ranged from 0.0034% (other impurities totaling approximately 0.03%) through 0.28 to 0.99% in carefully selected specimens of commercial steels and up to 1.11 to 3.40% in special iron-carbon alloys prepared by B.C.I.R.A. These were dry-machined to 3 x ⅝-in. rounds, weighing approximately 200 g.; also a series of smaller samples were prepared which weighed approximately 130 g. They were cleaned in carbon tetrachloride, acetone, and ether, and were carefully dried.

Both vacuum extraction and the absorption or pressure-drop method of Sieverts were used for the solubility measurements. The temperature range was 600 to 1000° C.

(Continued on p. 190)

*Digest of "Solubility of Hydrogen in Iron-Carbon Alloys", by B. G. Davies and T. Evans, *Foundry Trade Journal*, Vol. 97, July 29, 1954, p. 115-122.

MUFFLES • RETORTS • BELTS CHAIN
CARBURIZING BOXES • RAILS BELTS
ROLLER RAILS • SALT POTS MUFFLES
CHAIN • BELTS • POTS RETORTS
MUFFLES • RETORTS SALT POTS
BELTS • MUFFLES ROLLER RAILS
CHAIN • MUFFLES
RETORTS POTS
MUFFLES BELTS
BELTS CHAIN
SALT POTS ROLLER RAILS
CARBURIZING BOXES • BELTS TRAYS • CHAIN

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

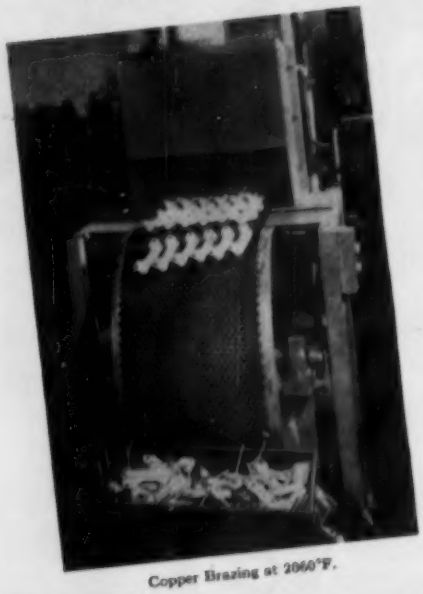
But make certain that you specify "ACCOLOY"

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY ENGINEERING & CASTING CO.
ALLOY CASTING CO. (Div.)
CHAMPAIGN • ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

Keep your product on the move . . .



Copper Brazing at 2060°F.

WITH

ASHWORTH

PROCESS BELTS

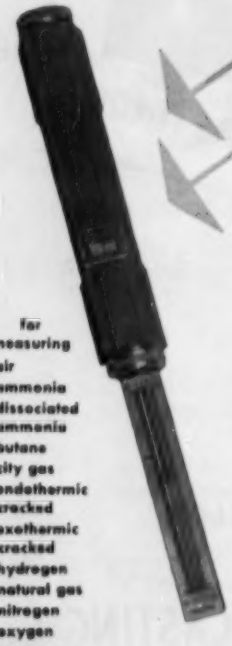
Woven from any metal capable of being drawn into wire form ASHWORTH belts afford a conveying medium in temperatures from sub zero to 2100°. Whatever your process—whether it be pickling, quenching, annealing, hardening or blueing—Ashworth belts can help you effect economies and

Keep Your Product on the Move

ASHWORTH BROS., INC.
METAL PRODUCTS DIV. • WORCESTER, MASS.

Sales Engineers: Buffalo · Chattanooga · Chicago · Cleveland · Detroit · Kansas City · Louisville · Los Angeles · New York · Philadelphia · Pittsburgh · Rochester · Seattle · St. Paul · Tampa
Canadian Rep., PECKOVER'S LTD. · Toronto · Montreal

WRITE FOR ILLUSTRATED CATALOG M52



WAUKEE FLO-METERS

. . for measuring industrial gases

Here at last is the truly modern flo-meter that offers important and exclusive advantages for every user.

1. **Easy to clean.** No tools are needed for disassembly . . can be completely cleaned and reassembled in 2 minutes.
2. **Easy to read.** 6" scale gives extra visibility. Exclusive Waukee tabs identify in large red letters gas being measured. Eliminates mistakes.
3. **Built-in control valves.** Operators can easily see flow change.
4. **Easy to mount.** Can be panel mounted . . piping is simpler, installation costs less.

For additional information request bulletin #201.

For measuring
- air
- ammonia
- dissociated ammonia
- butane
- city gas
- endothermic cracked
- exothermic cracked
- hydrogen
- natural gas
- nitrogen
- oxygen
- propane

Waukee **ENGINEERING COMPANY**

403 E. Michigan Street, Milwaukee, Wis.

Hydrogen . . .

(1112 to 1832° F.). The furnace was heated by a Kanthal wire winding which provided a 3-in. temperature zone varying only ± 2.5° at 1000° C. Tests were run in duplicate in ceramic tubes of two sizes, adapted to the two sizes of specimens. Pythagoras and mullite tubes were selected after tests showed a negligible hydrogen loss and no appreciable change in the tubes after several months of operation. A commendable degree of care was exercised throughout the investigation. The gas train was well-conceived; the hydrogen and argon were carefully cleansed by deoxidation and dehydration; equilibrium was approached from both sides of the given point; and adequate checks were made against effusion through the tube walls, occlusion within the metal and ceramic parts, decarburization of the metal, methane formation, and other side reactions. The gas analysis was obtained with a modified Haldane apparatus adapted to the measurement of carbon dioxide, carbon monoxide, oxygen, hydrogen and methane.

Results with purified iron and with Armco ingot iron showed close conformity with the 1932 classic in this field by Luckemeyer-Hasse and Schenck, sharp and important solubility increases appearing at A_3 and A_4 when ferrite transformed to austenite. Sieverts' Law, expressing the quadratic relationship between solubility and PH_2, was also confirmed, allowing the results to be corrected to 760 mm. with negligible error. The law was found to hold at 1000° C., even when the carbon content was importantly increased, since dissociation of methane at that temperature is almost complete. The relationship was still found to be reasonably close at 800° C., less so at 600° C.

As the carbon content of the commercial steels increased, the lower solubility shift moved downward to temperatures in the range of 725 to 825° C. (1337 to 1517° F.), in keeping with the altered A_3 boundary. The rate of solution increased, and there was a slight decrease in total solubility with a minimum near 0.50 to 0.55% carbon. Decarburization restored this boundary to the

(Continued on p. 192)

Quenching Media for Alloy Steels

This is the seventh of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

In the quenching of alloy steels, several points require consideration, among them being the size and shape of the piece, the type of steel involved, the quenching medium, and proper agitation of the quenching bath.

The composition of the steel has an important bearing on the selection of a quenching medium. As an example: shallow-hardening steels require a fast cooling rate, whereas deeper-hardening steels require progressively slower rates as the alloy content increases.

Three commonly used types of quenching media for alloy steels are water, oil, and air. These are discussed below in the order of quenching severity:

(1) WATER. Fresh water is entirely satisfactory only when used as a flush. Salt-water solutions are generally used in still baths to avoid the bad effect of bubbles resulting from dissolved atmospheric gas. It should be noted that the quenching rate drops as water temperature is increased. The range of 70 deg to 100 deg F is recommended.

(2) OIL. An oil quench cools more slowly than water, and faster than air. Oil-hardening steels can be hardened with less distortion and greater safety than water-hardening steels. Mineral oils are generally used because of their low cost and relatively stable nature.

(3) AIR. If sufficient alloying elements are present, critical cooling rates are decreased to the extent that certain steels can be quenched in either still or forced air.

While the choice of quenching medium is of prime importance, there is another factor that should not be overlooked. This is the agitation of the quenching bath. The more rapidly the bath is agitated, the more rapidly heat is removed from the steel, and the more effective the quench.

Bethlehem metallurgists will gladly help you with any problem related to quenching or other phases of heat-treatment. They are men of long practical experience in this field, and they understand fully the advantages and limitations of each method. Always feel free to call for their services; their time is yours, without obligation.

Remember Bethlehem, too, when you are next in the market for AISI standard alloy steels, special-analysis steels, or carbon grades. We are always in a position to meet your needs promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM ALLOY STEELS

BETHLEHEM STEEL

"Pete is writing a testimonial on, "Why I like BUSTER Alloy Shock Resisting tool steel!"

COLUMBIA TOOL STEEL COMPANY • CHICAGO HEIGHTS, ILL.

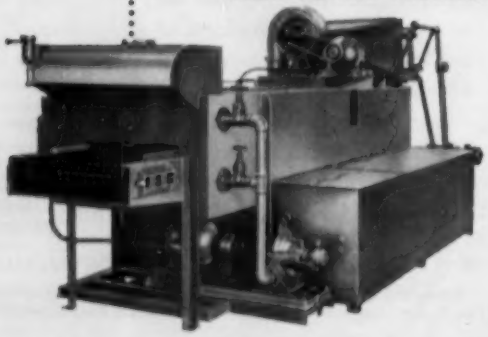
Producers of fine tool steels — All types immediately available through Sales Offices, Warehouses and Representatives in Principal Cities.

TOOL COLUMBIA STEELS

no job too complicated—
no job too unusual!

ALVEY-FERGUSON

CLEANING AND PROCESSING MACHINES



This special purpose A-F Washing Machine was built for one of the nation's largest automobile plants to remove grease and chips from rocker arm shafts after the machining operation.

A unique feature is the special type of A-F Bar Conveyor unit which provides maximum washing and drying area.

For a discussion of latest metal parts cleaning methods, write today.

THE ALVEY-FERGUSON CO.

163 Disney St. Cincinnati 9, Ohio

Offices or representatives in principal cities

Hydrogen . . .

expected position near 910° C. (1670° F.).

No important variation appeared below the transformation temperature for the special alloys containing more than 1% carbon; but, within the gamma phase the solubility increased to a maximum near 1.8% C for 1000° C., although the saturation value for this temperature is 1.55% carbon. This solubility maximum expressed itself at 1.6% carbon at 900, and 1.3% at 800° C. There were indications that the hydrogen in the cast irons was variously held (*a*) chemically by the metal, (*b*) chemically by the graphite, and (*c*) mechanically by occlusion in internal discontinuities.

These authors have provided some much needed and apparently dependable information on the behavior and the solubility of hydrogen in iron-carbon alloys. The principal conclusions are that (*a*) the ternary iron-carbon-hydrogen system is closely comparable to the binary iron-hydrogen, (*b*) carbon alters the solubility mainly through its influence on the ferrite-austenite relationships, and (*c*) the carbon somewhat alters the diffusion rate and also the total occlusion, both by its chemical bonds with the hydrogen and by its mechanical effect in developing internal voids through the formation of graphite.

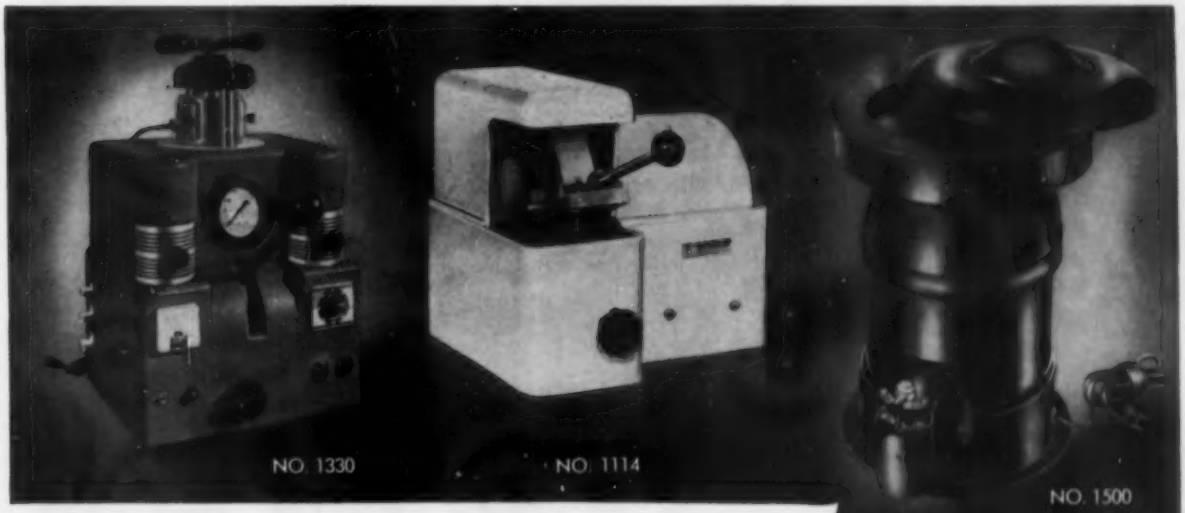
CARL A. ZAPFFE

Solidus and Liquidus of Highly Reactive Alloys*

THE CONVENTIONAL methods of determining the solidus and liquidus of an alloy system (either by cooling curves or by quenching from increasing temperatures) require considerable quantity of material and are inapplicable to rare metals. They also cannot be applied to very reactive metals which are easily contaminated by containers or furnace atmospheres.

(Continued on p. 194)

*Digest of "Methods for Determining the Liquidus Points of Titanium-Rich Alloys", by W. Hume-Rothery and D. M. Poole, *Journal* of the Institute of Metals, Vol. 82, June 1954, p. 490-492.



NEW MODERN, PRECISION BUILT MACHINES FOR THE METALLURGICAL LABORATORY ARE DESIGNED BY BUEHLER LTD.

NO. 1330 SPEED PRESS provides speedy and practical preparation of mounted specimens in either opaque bakelite or the crystal clear plastic compounds. Stainless steel mold assemblies produce 1", 1¼", and 1½" mountings.

NO. 1114 SPECIMEN CUTTER with sludge trap, for table top mounting. Total enclosed cutting assembly. Specimen holder and adjustable clamps on swing arm with operating handle. Enclosed ½ HP ball bearing motor.

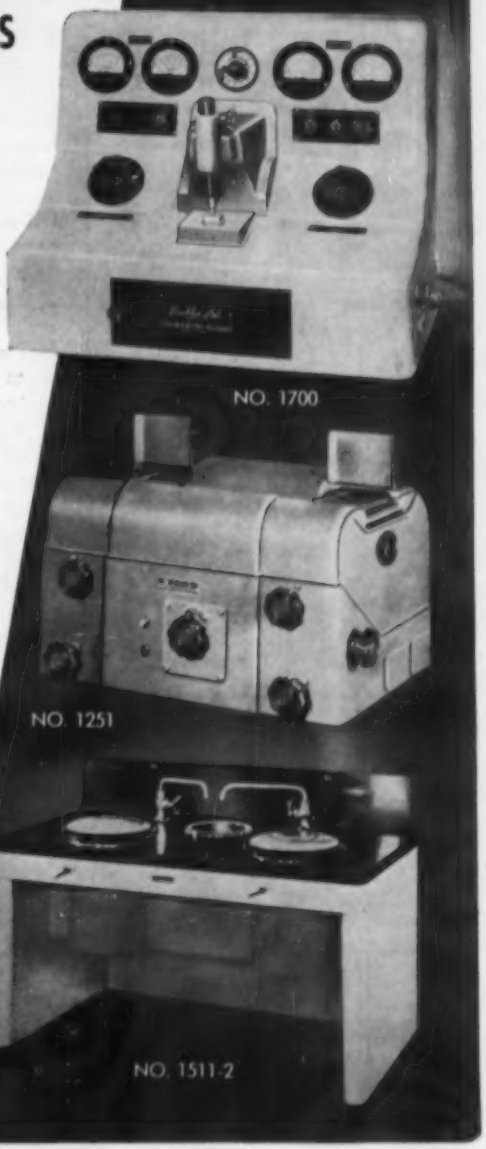
NO. 1500 STANDARD POLISHER produces accurately polished specimens with speed and ease. 8" diameter bronze wheel mounted to ¼ HP ball bearing motor. Speeds of 550 & 1150 r.p.m.

NO. 1700 NEW AB ELECTRO POLISHER produces scratch-free specimens in a fraction of the time usually required for polishing. Speed with dependable results is obtained with both ferrous and non-ferrous samples.

NO. 1251 DUO-BELT WET SURFACER is the most modern apparatus for the flat preparation of metallographic specimens. Two belts of different grits travel at speeds of 1600 & 3200 ft.p.m.

NO. 1511-2 DELUXE POLISHING APPARATUS has convenience of desk-top height. Wash bowl, two 12" swing spouts, two 8" removable wheels . . . one standard 1500 F and one low speed 1505-2 F polishing heads.

SEND FOR CATALOG OF OUR COMPLETE LINE.



Buehler Ltd.

METALLURGICAL APPARATUS

2120 GREENWOOD STREET
EVANSTON, ILLINOIS, U.S.A.

MERRILL
MATERIALS HANDLING
DEVICES

4 SIZES

LIFTING CLAMP

TWIN LIFTER

HAND GRIP

DRUM TILTER

4 SIZES

DRAG CLAMP

3-M-1

DRUM OPENER

MERRILL BROTHERS
56-31 ARNOLD AVENUE
MASPETH, N. Y.

Liquidus . . .

The new method, as applied specifically to a 76.5-23.5 Ti-Ni alloy, is as follows: Small containers as sketched in cross section were made of 5/16-in. rounds of pure titanium, and in the 5/32-in. cavity was placed a small sample of the alloy under study. Three were sealed in three

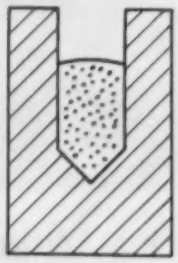


Fig. 1 – Sketch of Container

small silica tubes (argon atmosphere), and air quenched from 1184, 1206 and 1210° C. respectively, the container sectioned on its diameter, and the center examined under the microscope. At 1184° C. about half the alloy was melted, and the resulting microstructure contained relatively large crystals of undissolved solid and chilled liquid. After heating to 1206° C. very few crystals of undissolved solid remain; after 1210° C. the structure is of a completely chilled liquid. This would locate the solidus between 1206 and 1210° C. The titanium container was not attacked and analysis of the chilled liquid after the 1210° C. quench showed 78.7% titanium and 21.2% nickel. In other experiments with other alloys, attack on the container could easily be shown by rounding of the originally sharp corner at the apex.

To determine the liquidus temperature for the 76.5-23.5 Ti-Ni alloy (composition X in the phase diagram on p. 196) a series of cups would be made of it, a series of alloys containing progressively more nickel and less titanium formulated, (compositions S_1, S_2 . . .), and small samples of each placed in the alloy cups. These are then sealed in protective atmosphere heated as close to 1210° C. (temperature S_x) as possible without melting the cup itself, and quenched. The hypothetical phase diagram illustrates the prin-

(Continued on p. 196)

Somers
UNIGRAIN®
thin strip brass
for
deep drawing

Uniform fine grain size of Somers eyelet brass—less than .010 min. (75X).

with
Fine Grain Finish

Somers Brass Company is pleased to announce the availability of a new, unique annealing process which makes possible a uniform fine grain of less than .010 mm. which can be drawn to full 40% elongation.

Developed in cooperation with the Selas Corp. of America this new process makes it possible to deep draw Somers THIN STRIP and still obtain a fine grain which is easily buffed to a brilliant finish.

And this new Selas Furnace provides high production as well as close control of temper and uniformity. It is typical of the modern equipment with which Somers produces copper, brass and other alloys to rigid specifications between .010" and .00075".

If you have a problem with thin strip, let Somers experience help you. Write for confidential data blank or field engineer.

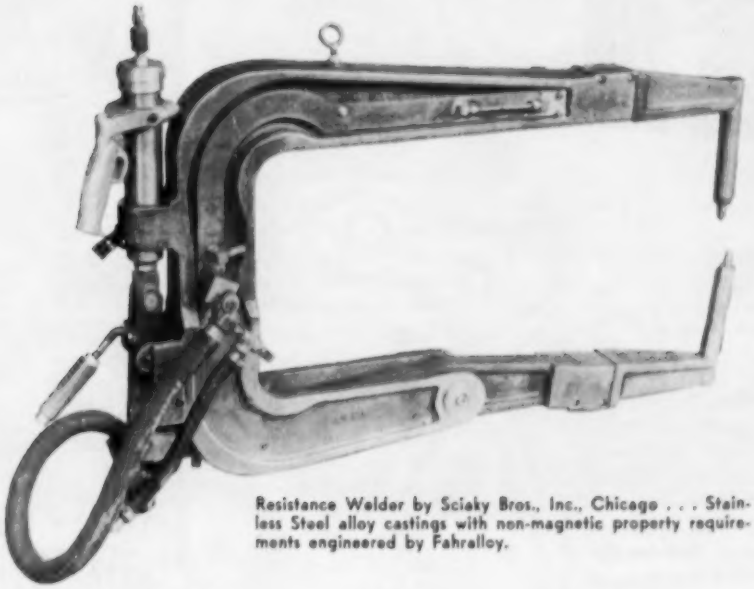
FOR EXACTING STANDARDS ONLY
MONEL • NICKEL • COPPER • ALLOYS
THIN STRIP

Somers Brass Company, Inc.
WATERBURY, CONN.

THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE

FAHRALLOY...

engineering experience is yours for the asking



Resistance Welder by Sciaky Bros., Inc., Chicago . . . Stainless Steel alloy castings with non-magnetic property requirements engineered by Fahralloy.

For over 20 years Fahralloy engineering experience has helped solve many stubborn problems involving high temperature or highly corrosive service conditions. It ranges all the way from roaster rabble arms to catalyst trays. The point is that no matter what your heat or corrosion problem may be . . . no matter how tough you may think it is you can have complete confidence that you'll get the right answer at Fahralloy. Remember, too, that Fahralloy engineering experience is something that can't be bought—but it's yours for the asking.

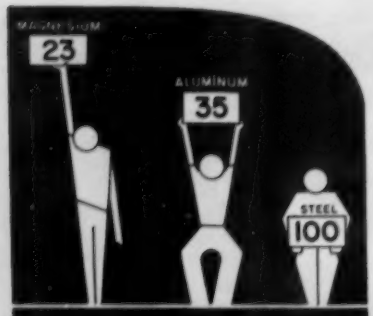
•

CLARE CHARRON • 209 Curtis Building • Trinity 5-7633
DETROIT Area Representative

•

THE FAHRALLOY CO.

150th & Lexington Ave. — Harvey, Illinois
In Canada — Fahralloy Canada, Ltd., Orillia, Ontario



IN THIS AGE OF LIGHT METALS—

What a Metal For You to Use!

The old fashioned idea was, "Make it heavy! The more weight, the more strength."

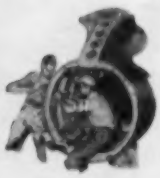
The modern idea is, "Reduce dead weight wherever possible."

Magnesium is the lightest of the modern metals. Aluminum is 50% heavier.

LET B & P WORK WITH YOU on any idea you may have about designing or redesigning in Magnesium. The advice of B&P engineers is yours with no obligation. Also, B&P has the finest of facilities to produce your product in Magnesium. Phone or write us.

Engineering & Design

Rolling Magnesium Sheet and Plate



Fabrication & Assemblies

LIGHTNESS ...PLUS

BROOKS and PERKINS Inc.

Pioneer Magnesium Fabricators

Rolled Magnesium Plate & Sheet
1958 W. Fort St. • Detroit 16, Mich.
TAshmoo 5-5900

Liquidus . . .

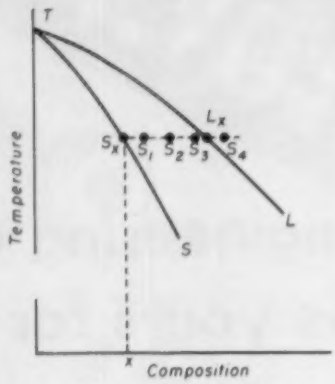


Fig. 2 – Hypothetical Phase Diagram Showing Principle of the Method

ciple. Alloy S, at temperature S_x would react slowly with the container to give some liquid of composition L_x, which could be spotted in a microscopic examination. Attack would be more rapid and extensive as the nuggets had compositions S_2 and S_3. A nugget with composition like S_4, the first one lying outside the liquidus, would attack its container rapidly and its microstructure would show only chilled liquid. A series of experiments of this sort with 83-17 Cu-Sn bronze bracketed the liquidus composition at 926° C. within 5%.

E.E.T.

Thermal Conductivity of Refractory Materials*

THE INFLUENCE of various factors on the thermal conductivity of compacted granular refractory materials is reported for the range of 20 to 1600° C. (68 to 2900° F.). Olivine and zircon sands were used in the investigation.

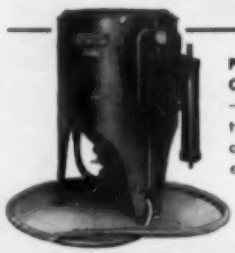
All of the sand mixtures contained 4% bentonite, three mixes had 4% water and two others had 2% and 5.5% water. The standard sand compacts prepared from the various mixes were 2 in. diameter and 3 in. long. These were made by placing

(Continued on p. 198)

*Digest of "Apparent Thermal Conductivities of Molding Materials at High Temperatures", by D. V. Atterson, *Journal* of the Iron and Steel Institute, Vol. 174, July 1953, p. 201-211.

PANGBORN BLASTS
by don herold

Cost-Cutting Story of the Pangborn Blast Cleaning Machine



Pangborn Blast Cleaning Machine —available in six types, stationary or portable—delivers efficient, low-cost maintenance in any plant. $188 up.

For details, write: PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Maryland.

Pangborn

BLAST CLEANS CHEAPER
with the right equipment for every job

LOCKHEED AIRCRAFT REPORTS:

"Our Baldwin FGT SR-4® testing machine is invaluable!"

"We don't have 'routine' production line tests . . . each test we get is likely to be entirely different from any we've run before," explains the Engineering Test Group of Lockheed Aircraft's Engineering Test Laboratory, Marietta, Ga. "That's why the new Baldwin-Emery FGT SR-4 Universal Testing Machine fits our needs so well. This single revolutionary machine is not only easy to operate and extremely accurate, but is flexible as well."

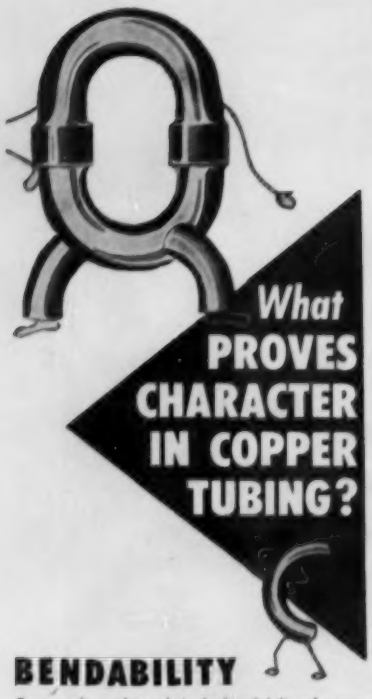
These photographs show just two of the diverse tests Lockheed is making on their 50,000 pound FGT machine . . . the closeup shows a round piece of aluminum stock being tested with the Baldwin SR-4 Extensometer added for accurate control . . . the smaller picture shows how Lockheed obtains the ultimate adhesion strength of a metal-to-metal bond within very accurate tolerances.

Your laboratory, too, will profit by using this unique, versatile testing machine . . . for any of these diverse tests; static tension, compression, flexure, torsion, creep, stress rupture, relaxation, or even shock tests on structures. For the full story on this example of Baldwin's "Packaged Precision Measurement," write us for our new Bulletin 4206. Address: Dept.2424, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

TESTING HEADQUARTERS

BALDWIN-LIMA-HAMILTON

General Offices: Philadelphia 42, Pa. Offices in Principal Cities
In Canada: Peacock Bros., Ltd., Montreal, Quebec



BENDABILITY

Temper plays a key role in the bendability of copper tubing. United Copper Tubing gives you the uniform grain structure and controlled temper which are ideally suited for bending.

EXPANSION FACTORS

When specifications call for mechanical or hydraulic expansions, the tube that makes the requirement without failure has the type of built in character you can depend on!

It is in extreme use that really good copper tubing identifies itself and copper tubing character is firmly established in United Copper Tubing.

UNITED

COPPER TUBING HAS THESE MAJOR CHARACTER ASSETS AT THE START

Completely Uniform Temper
Sparkling Cleanliness Inside and Out
Tolerances Precisely as Called For (down to the closest!)

UNITED

COPPER TUBING HAS THE DEPENDABLE "USE" CHARACTERISTICS YOU WANT IN YOUR COPPER TUBING

UNITED WIRE

AND SUPPLY CORP. Permanently United PROVIDENCE, R. I.

Conductivity . . .

the sand mix in a core box and then slowly compacting in a manually operated hydraulic press. This technique, in contrast to ordinary ramming, produced a compact of substantially uniform density. The resulting green sand compact was dried in an electric oven and its dry density could then be determined by mensuration.

In preparing the sand compacts, three steel rods, 3 mm. diameter, were inserted before compacting. One of the rods was in the central axis of the compact and the other two parallel to it but at different radial distances from the center. After the compacts dried, the steel rods were removed and alumina tubes were then sealed into the holes with a small quantity of silica wash. A platinum heating wire was inserted into the central tube and two platinum thermocouples were fixed into the other two holes to measure the temperature at these locations.

Conductivity measurements were made on the prepared compacts by assembling them in a very carefully insulated furnace. The whole apparatus was brought to a steady temperature, current was then introduced into the central platinum heating wire (the furnace meanwhile was controlled at the desired testing temperature) and the temperatures of the thermocouples at the two radial distances from the center were recorded.

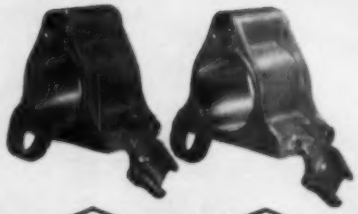
The furnace for testing the sand compacts employed a wound molybdenum heating element which was capable of producing temperatures from 20 to 1600° C. The protective atmosphere for the windings was 90% nitrogen and 10% hydrogen which had been carefully purified to remove oxygen, water, and carbon dioxide. The compact temperature was controlled within 2° C. with this equipment. A detailed drawing of the assembly is given in the paper. The test compact was heated in air.

Thermal conductivities were determined at temperatures of 100, 500, 750, 1000, 1100, 1200, 1300, 1400, 1500 and 1600° C. At each temperature the furnace was held constant while the center heating wire was heated. The two thermocouples inserted into the compacts

(Continued on p. 200)

Lorco **NOW...**

YOU CAN TUMBLE PARTS YOU NEVER BEFORE CONSIDERED COULD BE TUMBLED . . . WITH LORCO TUMBLING COMPOUNDS



BEFORE AFTER

ALUMINUM YOKE, 5.5 lbs.
Tumbled loose in LORCO ZA Compound.

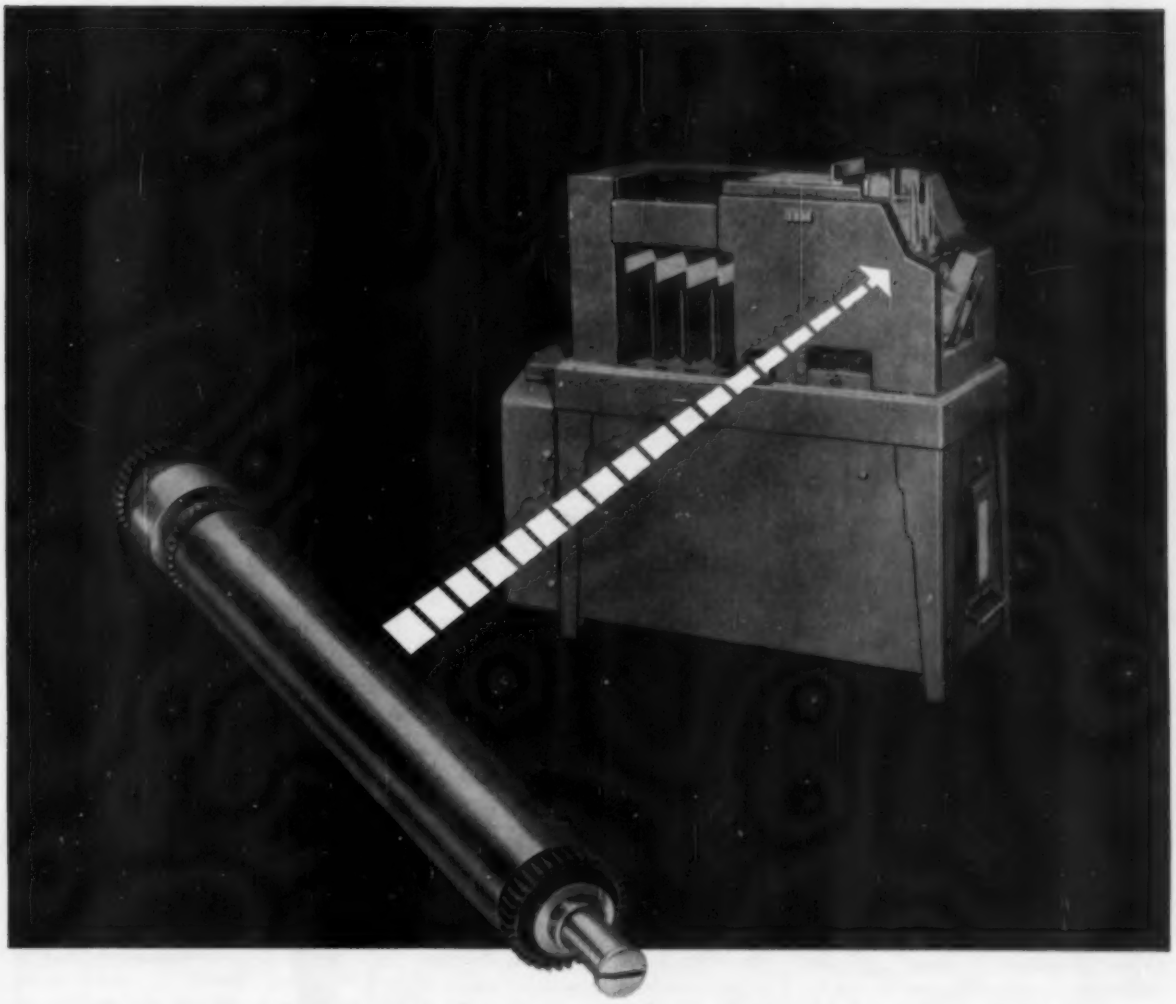
Amazing, but true! LORCO TUMBLING COMPOUNDS clean, degrease, deburr, color and finish parts you previously thought unsuitable for barrel finishing. LORCO Compounds increase metal finish, luster and color, while adhering to close tolerance of low, micro-inch finishes . . . and do it in reduced time cycles.

LET US PROVE IT TO YOU!

Without obligation, send us sample parts along with your blueprint specifications. We will accurately finish your parts and return them promptly with a detailed processing report. By arrangement, one of our engineers will personally help you with any finishing problems in your plant. Write for your copy of our fact-filled Catalog on all LORCO Compounds. Inquire also about LORCO TUMBLING BARRELS AND TUMBLING MEDIA.

LORD CHEMICAL CORPORATION

2068 S. Queen Street York 5, Pennsylvania



Out of IBM's Collator pops a tubing idea for you!

This is IBM's Collator—a mechanical super-accountant that shuffles, selects, matches and merges punched cards at the rate of four per second!

Heart of this electronic gee-whizzer is an extraordinary kind of tubing—a contact roll over which the cards must pass. Eighty miniature, hard steel brushes finger each card as it skims by—penetrate it through pre-punched holes, touch the contact roll and close the electronic circuit—flipping the card into the right slot.

Collator contact rolls must have good wear resistance to stand this high-speed workout. And they must resist corrosion and be good electrical conductors. So IBM employs Superior WELDRAWN* Beryllium Copper and low carbon steel composite tubing for Collator contact rolls. This tubing meets IBM's tight specifications for wear resistance, peak hardness and conductivity. Superior supplies the composite tube in 1 1/8" O.D. with .049" wall.

When tubing troubles put the hex on your plans, call on Superior.

We have years of experience, the modern test and development facilities, and more than 55 analyses in many metals to unravel your problem. Write for a copy of our new Technical Bulletin #7-2 on Seamless and WELDRAWN* Beryllium Copper Tubing. Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium

Superior Tube

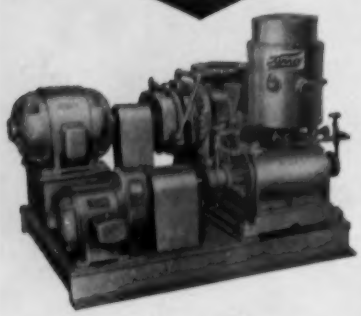
THE BIG NAME IN SMALL TUBING

All analyses .010" to 1/8" O.D.
Certain analyses in light walls up to 2 1/2" O.D.

West Coast: Pacific Tube Company
5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

*Reg. U.S. Pat. Off.

NEED HIGH CLEAN VACUUM FAST?



The new Kinney Model KMB Vacuum Pump produces eight times more vacuum pumping speed per pump horsepower than any other mechanical vacuum pump! Unique in principle and revolutionary in performance, this two-stage positive displacement pump produces a clean, high vacuum specially suited for modern high vacuum metallurgical processes . . . there's no liquid sealant in the main rotor unit to backstream into the vacuum system and contaminate the process. The second stage pump can be equipped with the Kinney **Controlled Gas Ballast** valve to prevent vapors condensing within the pump . . . keeps oil clean for continuous operation. Learn more about this latest addition to the largest line of mechanical vacuum pumps. Write for our new Bulletin 400 or contact one of our competent vacuum engineers in the Kinney district office nearest you.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3564 WASHINGTON STREET • BOSTON 30 • MASS.

Please send Bulletin 400.

Name_____
Company_____
Street_____
City_____ State_____

Conductivity . . .

reached an equilibrium temperature in 1 to 5 hr. and from these readings the thermal conductivity could be calculated. Two or more readings at each furnace temperature were made by using varying power inputs in the central heating wire to develop different thermal gradients in the sand compacts.

Charts showing the thermal conductivity of the various test compacts against temperature exhibit significant results. Generally, the conductivity decreased in the temperature range of 20 to 500° C., but then increased very rapidly in the range 600 to 1600° C. The conductivity between 500 and 1500° C. was quite similar for most samples. Readings showed about 2×10^{-3} cal. at 500° C. and between 3.5 and 5.0 $\times 10^{-3}$ cal. at 1500° C. The chemical composition of the refractories was not important but the grain size and density of the compacts had a large effect.

The authors deduce that between 20 and 500° C. actual thermal conduction between the grains was the main mechanism of heat transfer and the drop in conductivity here is due to decrease in the true thermal conductivity of the sand particles. Above 600° C., the apparent thermal conductivity increased mainly because of greater heat transfer by radiation within and between particles. Other workers have calculated thermal conductivity above 500° C., assuming all transfer by intergranular radiation, and it was found that the apparent thermal conductivity of the readings made in this investigation fitted the theoretical equation quite closely at temperatures up to 1300° C. The expression, derived by Schwartz, is as follows:

$$K = K_0 + ArT^3$$

where K is apparent thermal conductivity, K_0 is true thermal conductivity, r is mean radius of sand grains, T is absolute temperature, and A is a constant. Above 1300° C. the apparent conductivity increases at a much lower rate and the data do not fit the mathematical expression. This effect is attributed to the sintering action which begins around 1300° C. and causes slagging, chemical changes and alteration of the voids between

(Continued on p. 202)

QUICK— ACCURATE Temperature Readings in Non-ferrous Molten Metals with

XACTEMP
Trade Mark Reg. U.S. Pat. Off.
HAND PYROMETERS

Accurate to Within a Fraction of a Scale Division

The XACTEMP PYROMETER makes possible better quality control and helps toward elimination of blowholes, burnouts, sand infiltration and other flaws due to incorrect temperature . . . affords a simple, effective means for accurate temperature measurement of molten, non-ferrous metals. Well-balanced, easy to handle . . . always ready for use and requires no preliminary adjustments.

Cast aluminum and brass construction. Indicator is of medium resistance not affected by thermocouple length . . . acts rapidly . . . provided with Alnico V magnet and direct reading dial starting at 50° F. 43" stainless steel extension . . . standard 7" Marshall tip permits true readings below surface of metal. Made to give good service for years. Order at once to be sure of immediate delivery from stock.

Catalog No. MM701 Complete with Thermocouple.. **$68.50**

Catalog No. 1449-501T Replacement Thermocouple Tip..... $7.00

Ask about XACTEMP PYROMETERS for all-around general temperature checking. A full line of thermocouples available in stock.

GORDON SERVICE

CLAUD S. GORDON CO.
Manufacturers & Distributors
Thermocouple Supplies • Industrial Furnaces & Ovens
Pyrometers & Controls • Metallurgical Testing Machines
Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

information memo from the engineering laboratories of CONSOLIDATED VACUUM CORPORATION

CVC

Volume 1 Number 1

HIGH VACUUM METALLURGY

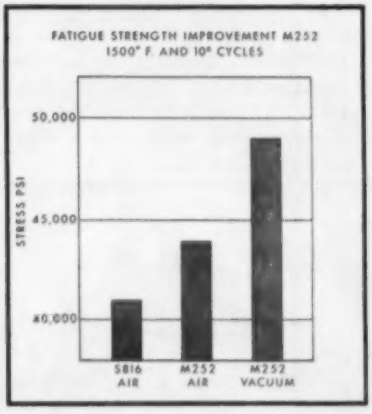
A new technique

High vacuum metallurgy is opening a new frontier for the metals industry.

High-purity metals and high-temperature alloys having physical characteristics far superior to air-processed metals are now produced commercially in high vacuum. Volume production has risen from poundage to tonnage in less than five years' time.

The value of vacuum-processed metals can be illustrated with a high-chromium stainless steel alloy whose impact strength at room temperature is increased 50 to 1 over the same air-melted alloy.

The increase of fatigue resistance of another alloy is shown graphically below. Fatigue resistance, rupture strength, tensile strength, tensile ductility, and forgeability are a few of the characteristics noticeably improved by vacuum processing.



The strength of a metal or alloy depends to a considerable extent upon the kind and amount of impurities it contains —impurities such as oxygen, nitrogen, carbon, or other unwanted elements which are inherent in the metal or which the metal picks up from the air or from the crucible.

High vacuum metallurgy produces metals and alloys wherein the level of contamination by such impurities is considerably reduced. It gives . . .

1. closer control of the alloying elements throughout the processing cycle;

2. separation of undesirable gases and other contaminating elements from the melt;

3. alloys and metals which are impossible or impractical to produce in air or inert gas.

End products show marked improvements in such operations as annealing, sintering, soldering, brazing, outgassing, distillation, refining, as well as melting and casting.

Large-capacity pumping is the key to production economy

A high vacuum furnace is no better than its vacuum pumping system.

A pumping system is rated on its "throughput" and its ability to handle "gas load."

Throughput is the quantity of gas flowing through the high vacuum pumps in a given period of time over a given pressure range. Double the speed of these pumps and the throughput of the system is also doubled.

Gas load is the quantity of gas to be removed from the furnace in order to create and maintain the gas-free atmosphere required throughout the processing cycle.

Initially, the vacuum furnace is exhausted with a mechanical pump. This "roughing" operation removes the greater portion of the gas present at the start of the cycle. When the mechanical pump has reduced the pressure to the practical limit of its capacity, the high vacuum vapor pump is used because of its large pumping capacity in the low-pressure region. A properly designed system will reduce the pressure in a furnace to one 50-millionth of an atmosphere in a matter of minutes.

If it were only necessary to remove the original gas load in the furnace chamber, it would be simple to calculate the proper capacity of the pumping system. Gas load, however, is not a static condition. The operations and reactions that occur in the furnace during the heating and melting cycle cause numerous surges in pressure.

Basically, these are the contributing factors:

1. entrapped gases that rising temperatures release from the chamber walls, the crucible, molds, and other in-vacuum surfaces;

2. outgassing from the main charge and alloy additions;

3. reactions between melt and crucible, and between insulation and crucible;

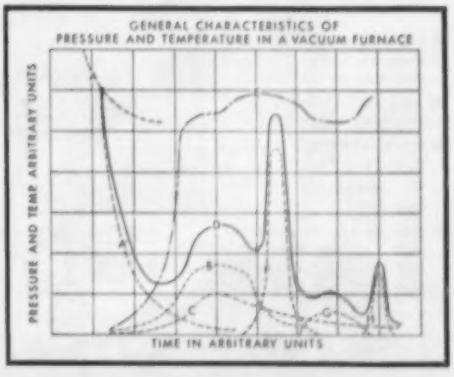
4. intended reactions such as oxygen reduction treatments;

5. inleakage from any points in the system.

The accompanying graph shows the relationship between these load surges and the resultant chamber pressure.

In order to maintain complete control over the reactions that take place in a furnace, the pumping system must have the capacity to handle these pressure surges with sufficient ease and to return the chamber rapidly to the required operating pressure.

There are other important factors which influence the design of a high vacuum furnace installation; some are technical and some economic. We welcome the opportunity of discussing your high vacuum metallurgy problems. For further information, please contact ***Consolidated Vacuum Corporation, Rochester 3, N. Y.*** (a subsidiary of Consolidated Engineering Corporation, Pasadena, California).


GENERAL CHARACTERISTICS OF
PRESSURE AND TEMPERATURE IN A VACUUM FURNACE
PRESSURE AND TEMP ARBITRARY UNITS
TIME IN ARBITRARY UNITS

Typical pressure-temperature curves for a high vacuum melting and casting furnace.

A—Mechanical pump evacuation on empty chamber
A'—Vapor pump evacuation on empty chamber
B—Outgassing from metal
C—Outgassing from insulation
D—Resultant pressure
E—Temperature of metal
F—Outgassing of alloy additions and deoxidizers
G—Outgassing due to solubility decrease
H—Outgassing during pouring

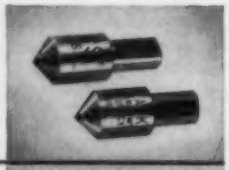
Consolidated Vacuum Corporation, ROCHESTER 3, NEW YORK

Sales offices: New York, N. Y., Chicago, Ill., Boston, Mass., San Francisco, Calif., Camden, N. J.

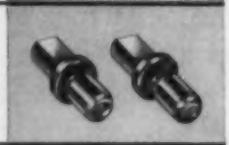
Call on CLARK

for All Your "Rockwell Testing" Needs

CLARK Diamond Cone Penetrators are exactly right for your "Rockwell" hardness tester, whether or not it bears the CLARK name. Every step in their manufacture, from careful diamond selection to expert lapping, leads to a precision product that will give you precision results. Yet CLARK Diamond Penetrators cost surprisingly little.



CLARK Steel Ball Penetrators, for accurate "Rockwell testing" of unhardened steel, cast iron, brass, bronze, and similar materials, are available in all standard sizes.



CLARK Test Blocks, in various hardness grades, provide a quick, sure, and simple method of checking the accuracy of your "Rockwell" type hardness tester.

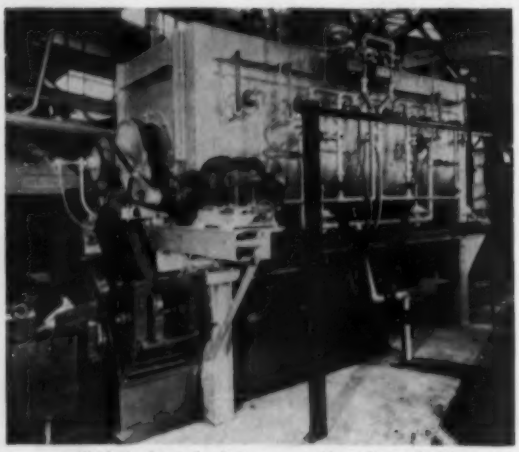
Write today for descriptions and prices.

CLARK INSTRUMENT, INC.
10202 Ford Road • Dearborn, Mich., U.S.A.

CLARK

make small parts heating—
Automatic · Continuous · Uniform

ROCKWELL
Revolving Retort
FURNACES



- For annealing, hardening, drawing metal products that may be tumbled.
- Automatic loading — No charging attention.
- Work uniformly heated throughout retort.
- No conveyors to heat and cool.
- Furnace may be combined with cooling, quenching and cleaning processes in automatic system.

Made in 4 standard sizes; gas, oil or electric heating. Also special sizes. Write for Bulletin 424R.

W. S. ROCKWELL COMPANY
FURNACES • OVENS • BURNERS • VALVES • SPECIAL MACHINERY
2045 ELIOT STREET • FAIRFIELD, CONN.
Sales Representatives in Principal Cities

Conductivity . . .

the grains. The amount of heat transferred in unit time by radiation between grains would be expected to decrease under these conditions.

Compacts containing coarser sand grains had a higher conductivity at all temperatures and this agrees with the factor r in the equation. Compacts of higher density obtained by drying at higher temperature also showed higher conductivity. When the amount of binder (bentonite) was increased from 4% to 6.5 and 10%, the conductivity increased slightly in the temperature range between 20 and 500° C.

The zircon sand yielded results quite similar to those obtained with silica sand – the same conductivity with about the same rate of increase as the temperature rose. The olivine sand has a slightly lower apparent conductivity than silica or zircon sand below 500° C. Between 500 and 1000° C. its conductivity increases rapidly in accordance with the cube of the absolute temperature. However, above 1000° C., this magnesium-iron silicate undergoes chemical changes and the rate of conductivity increase with rising temperature decreases. For example, at 1400° C. the apparent thermal conductivity of the olivine is about 2.8×10^{-3} cgs. units while the conductivity of the zircon sand is about 4.2×10^{-3} cgs. units.

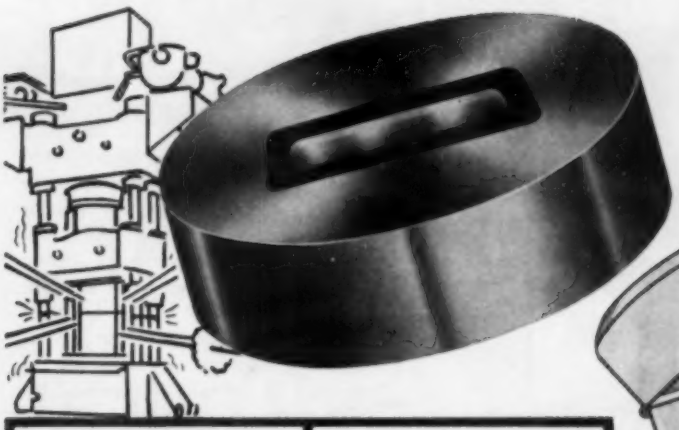
E. C. WRIGHT

Two Mg-Zr Casting Alloys*

IN RECENT years a series of magnesium alloys containing zirconium has been introduced based on the effect of zirconium in reducing the grain size. In the range of 0.2 to 0.7% Zr, the relation of grain size to zirconium content is linear. These results were obtained from different specimens solidified under identical conditions. The most interesting characteristics of magnesium-zirconium alloy castings are their

(Continued on p. 204)

*Digest of "Mechanical Properties of Two Magnesium-Zirconium Casting Alloys (Z5Z and RZ5)", by Raoul Pradeau, *Fonderie*, Vol. 101, June 1954, p. 3999-4006.



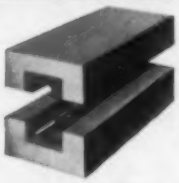
12,979,660 LIGHTER CASES WITH TALIDE DIES

A leading producer of cigarette lighter cases was experiencing considerable trouble using steel dies. An excessive number of lighter cases were being scrapped due to tears and deformation. Die cost was running $.028 per lighter. Operation involves drawing .020" thick carbon steel on A-3 Niagara presses, 45 strokes per minute.

Our die engineers were called in, and after installing specially designed Talide dies on customer's press line, rejects were eliminated, as well as time previously spent in buffing and polishing the cases after drawing. Subsequent plating expense was reduced ⅓ due to the smoother surface on the cases drawn.

The original 15 Talide dies placed in production have now drawn a total of 12,979,660 cases for an average life of 865,310 per die. Previous steel dies produced an average of 15,000 cases per die. Die life was therefore increased 58-1 after the installation of Talide dies.

Die cost has now been reduced to $.0008 per lighter drawn, and customer estimates his saving for the past year, using Talide dies, has been at least $25,000.



SWAGING DIES

Leading Fountain Pen Manufacturer cold swages 33 times more stainless steel parts with TALIDE dies.

HEADING AND EXTRUSION DIES

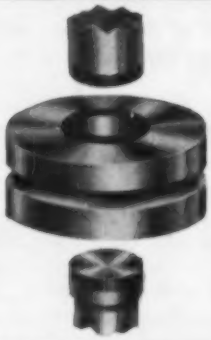
Cold-heading ¾" carriage bolts, TALIDE dies produced 1,500,000 pieces, steel dies only 50,000.

SHEET METAL DIES

137,000 hi-alloy steel Pressure Vessels drawn with TALIDE, against only 7,900 with steel dies previously used.

CURLING ROLLERS

TALIDE Curling Rolls last 65 times longer than steel rolls on beverage can forming operation.



POWDERED METALLURGY DIES

Pill dies of TALIDE metal outlast steel dies 100 to 1 while reducing rejects 82%.

BLANKING AND FORMING DIES

70 times more paper discs blanked out with TALIDE—over hard alloy die.

IMPROVED QUALITY

Additional refinements and improvements in our process have added still longer life to the wearing edges of Talide tools, dies and wear-resistant parts. The result is a carbide having a new, unique grain structure with harder and tougher properties than previous grades. Laboratory tests reveal our improved grades possess 25% greater strength and rigidity. Service life per grind up to 50% longer than previous grades has been proven in grueling field tests.

"Year after year—you can rely on TALIDE METAL for uniform results and consistent quality."
METAL CARBIDES CORPORATION
MC
TALIDE®
YOUNGSTOWN 7, OHIO
HOT PRESSED AND SINTERED CARBIDES · VACUUM METALS
HEAVY METAL · CERMETS · HIGH TEMPERATURE ALLOYS
OVER 25 YEARS' EXPERIENCE IN TUNGSTEN CARBIDE METALLURGY

Send for new 84-page Catalog 55-G or ask for sales engineer to call.

Rapid
RESISTANCE TESTING

with the Rubicon
LIMIT BRIDGE

Built for speedy, accurate production testing of resistors, coil windings, heater elements, percussion caps and other similar items where inspection costs must be minimized.

- Wide Range — 1 ohm to 10 megohms.
- Simple — for use by unskilled operators.
- Fast — speeds of 2000 items per hour possible.
- Sturdy — for year in and year out service.
- Spotlight Index — for easy reading.
- Versatile — suitable for rapid sorting into numerous tolerance bands.
- External Standards — permit automatic temperature compensation when required.

Fully described in Bulletin 100

RUBICON COMPANY
Electrical Instrument Makers
3758 Ridge Avenue · Philadelphia 32, Pa.

60 lb. PRODUCTION FURNACE
fast, high quality, economical heats

If you want a top-notch furnace for limited production, get this Type GMS 30 k.w., 60-lb capacity DETROIT. Indirect arc melting, automatic rocking control with 3-phase reversible motor, independently mounted electrode brackets for easy shell change. Rocking action assures thorough homogeneity of metals, economical heat utilization, longer lining life. For ferrous and non-ferrous alloys. Sold complete with transformer.

Write today for full information on Type GMS Detroit Electric Furnace.

FEMA

DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY
1080 26th St. • BAY CITY, MICHIGAN

Foreign Representatives: In BRAZIL—Equipamentos Industrias "Eisa" Ltd., Sao Paulo; CHILE, ARGENTINA-PERU and VENEZUELA: M. Castelli Inc., 150 Broadway, New York 7, N.Y., MEXICO: Cosco, S. de R. L. Atenas 32, Despacho 14, Mexico City, D. F.

Mg-Zr Alloys . . .

homogeneous structure and their low microporosity.

Since Z 5 Z* (4.5% Zn and 0.7% Zr) has a low specific gravity and good mechanical properties at room temperature, it is used for making highly stressed aircraft parts that are submitted to temperatures below 248° F. Its casting properties are generally excellent but it is prone to hot shortness; therefore large complicated castings are difficult to make. This difficulty is overcome by adding 1.3% rare-earth metals to Z 5 Z. The resulting alloy, RZ 5, has been adopted in the manufacture of complex castings.

The author has compared the mechanical properties (ultimate tensile strength, yield strength and elongation) of Z 5 Z using three kinds of test bars: (*a*) those cast separately in a special mold used for making bars for checking the metallurgical quality of the melt; (*b*) test bars that are adjacent to the casting; and (*c*) bars machined out of castings. The purpose of those listed under (*c*) is also to check the quality of the melt. However, they are not as representative of the quality as separately cast test bars because they are influenced by the feeding conditions of the casting and by their position on the casting. The third group are also influenced by the casting, feeding and cooling conditions of the castings.

The area of the reduced section of the test bars was 0.116 sq. in. for the separately cast test bars and 0.018 sq. in. for the other two types of bars. The elongation was calculated on a length equal to 8.16 $\sqrt{S_o}$, S_o being the initial area of the reduced section.

Z 5 Z was heat treated for 16 hr. at 390° F., and air cooled; RZ 5 was heated for 2 hr. at 625° F., air cooled, then heated for 16 hr. at 390° F. and air cooled.

Table I gives the average ultimate tensile strength, yield strength, and elongation for Z 5 Z and RZ 5.

The results show that separately cast test bars are suitable for checking variations in the metallurgical quality of the melt. The properties of test bars that are adjacent to cast-

(Continued on p. 206)

*Magnesium Elektron Ltd.'s designations.

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

NATIONAL ENGINEERING SERVICE

on

Heat and Corrosion Resistant Castings

General Alloys Company products are backed by a national engineering service offering unexcelled mechanical and metallurgical Heat and Corrosion Resistant Alloys for all Defense and Industrial applications.

"There is no substitute for Experience"

GENERAL ALLOYS BRANCH OFFICES AND REPRESENTATIVES

BALTIMORE, Maryland
Emil Gathmann, Jr.
813 Park Avenue

BUFFALO, New York
Roy E. Lynd
812 Tacoma Ave.

BIRMINGHAM, Alabama
Ray F. Friese
Harry G. Mozat
1247 American Life Bldg.

CHICAGO, Illinois
General Alloys Company
Edward T. Connolly
224 S. Michigan Ave.

CLEVELAND 15, Ohio
E. E. Whiteside
2254 Euclid Ave.

DENVER, Colorado
Tracy C. Jarrett
95 S. Ammons St.

PHILADELPHIA, Pa.
John P. Clark Co.
124 S. Easton Road
Glenside, Pa.

DETROIT 2, Michigan
General Alloys Company
Don S. Hutchins
2-147 General Motors Bldg.

FORT WAYNE 8, Indiana
The George O. Desautels Co.
P. O. Box 1176
R.R. 14, No. Bend Drive

HOUSTON 3, Texas
Wm. E. Brien Co.
1812 Posse Ave.

PITTSBURGH 15, Pa.
Vincent C. Leatherby
400 So. Main St.
Sharpsburg 15, Pa.

LOS ANGELES, California
Davis-Gregg Company
405 S. Main Street

LOUISVILLE 7, Kentucky
The George O. Desautels Co.
4003 Hycliffe Avenue

INDIANAPOLIS 8, Indiana
The George O. Desautels Co.
2302 N. Meridian Street
P.O. Box 7011

ST. LOUIS 16, Missouri
Associated Steel Mills, Inc.
3163-65 Morganford Road

MUNCIE, Indiana
The George O. Desautels Co.
P.O. Box 776
405 Wyser Block

NEW ENGLAND
David L. Ellis
Woodland Road
West Concord, Mass.

NEW YORK 7, New York
General Alloys Co.
Alfred M. Sampter
50 Church Street

GENERAL ALLOYS COMPANY

405 WEST FIRST STREET BOSTON, MASS.

"OLDEST AND LARGEST EXCLUSIVE MFRS. OF HEAT & CORROSION RESISTANT CASTINGS"

G-A ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

RHODIUM PLATING

Improves Contact Performance

With These Unbeatable Qualities:

- **hard, corrosion-resistant, electrical contact surface**
- **assures low and stable contact resistance**
- **allows higher pressures to be used in sliding contacts**
- **not affected by atmospheric changes**
- **oxide-free contacts eliminate partial rectification and unwanted signals**
- **provides low noise level for moving contacts**
- **extremely long-wearing**

These exceptional properties of RHODIUM plate assure greater efficiency; as a result, it is widely adaptable for electrical and electronic applications. RHODIUM plated contact surfaces are resistant to surface corrosion under all atmospheric conditions, proving extremely efficient in the field of high and ultra-high frequency.

Write for free, detailed booklet on RHODIUM PLATING.

BAKER PRECIOUS METALS

113 ASTOR ST., NEWARK 5, N. J.

NEW YORK • SAN FRANCISCO
CHICAGO • LOS ANGELES

Mg-Zr Alloys . . .

ings are in better agreement with those machined from the castings than with the bars cast separately. Although the mechanical properties are close for the two former groups, less variation occurred within the first-mentioned group.

Test bars machined from castings do destroy the castings but are useful in checking the adequacy of molding conditions. Because these test bars were taken from castings of various sizes and shapes, their results show greater dispersion than for the other types of bars used.

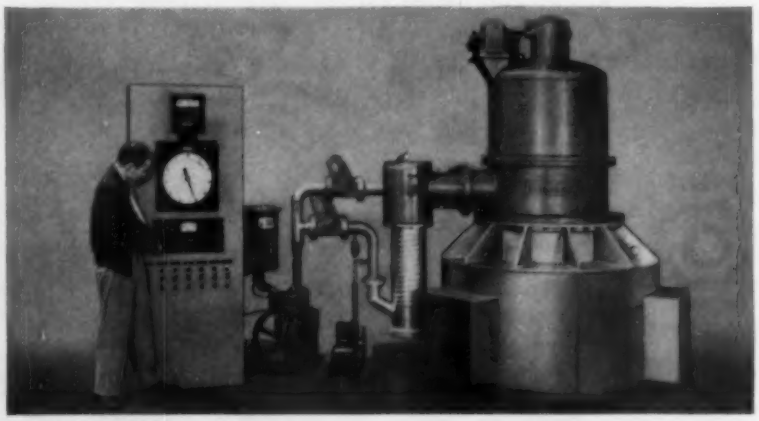
Comparison of results obtained with Z 5 Z and RZ 5 indicates that Z 5 Z has higher ultimate strength and elongation than RZ 5; however the yield strength of the latter is only slightly inferior to that of Z 5 Z. Results obtained with RZ 5 show less dispersion than those obtained with alloy Z 5 Z.

Another point that is worthy of mention is that due to its low susceptibility to hot shortness RZ 5 has good weldability. It should be noted that the author insists on the fact that the results given in this paper are representative of several months of industrial production.

A. COUTURE

Table I — Mechanical Properties of Magnesium Alloys Z 5 Z and RZ 5

TEST BAR	TENSILE STRENGTH, PSI.		YIELD POINT		ELONGATION, %	
	Z 5 Z	RZ 5	Z 5 Z	RZ 5	Z 5 Z	RZ 5
Separately cast test bars						
Design No. 1	36,200	28,900	21,600	20,900	5.5	3.2
Design No. 2	39,800	30,100	22,000	20,900	7.5	3
Adjacent test bars	37,300	29,300	21,600	—	6.6	3.3
Bars taken from castings	37,900	29,300	21,600	—	7	3.2



HI-VAC improves Titanium!

To prevent jet plane parts from disintegrating at supersonic speeds, aircraft manufacturers vacuum anneal Titanium parts in HI-VAC Annealing Furnaces. By removing the hydrogen (present to some degree in all Titanium) and other unwanted gases during the annealing cycle, the parts have greater strength and fatigue resistance to withstand elevated temperatures and stresses.

You can greatly improve the quality of active metals by vacuum annealing with HI-VAC Annealing Furnaces . . . also many brazing operations can be handled in these furnaces at lower costs than with other methods without danger of scaling or nitriding.

HI-VAC has designed and built the majority of large high vacuum annealing furnaces now in use and has a vast amount of *practical* experience to help you. *Send for complete information on High Vacuum Annealing Furnaces . . . or outline your problem in handling heat sensitive materials.*

High Vacuum Equipment Corporation

HI-VAC

349 Lincoln Street • Hingham, Massachusetts
vacuum furnaces for • melting • annealing • brazing

NOW AVAILABLE IN CLOTH-BOUND EDITION

Metals Handbook New 1954 Supplement

Order now a copy of the 1954 Supplement bound in red cloth to match your 1948 ASM Metals Handbook. The Supplement contains recent, authoritative information on all these subjects:

- **Carbon and Alloy Steels**
- **Tool Steels**
- **Stainless Steels**
- **Heat-Resisting Alloys**
- **Nodular Cast Iron**
- **Aluminum**
- **Copper**
- **Magnesium**
- **Titanium**
- **Engine Metals**
- **Stress Concentration**
- **Shot Peening**
- **Ferrous Castings**
- **Brazed Joints**
- **Heat Treating**
- **Metal Cleaning**
- **Press Forming**
- **Machining**
- **Powder Metallurgy**
- **Steel Melting**
- **Nondestructive Inspection**
- **Metallography**

This handsome 200-page volume contains 24 articles supplementing the 1948 ASM Metals Handbook. Prepared by 22 ASM technical committees, it has 326 illustrations, 155 tables. It makes a worthy addition to your technical library, one you'll refer to often.

For complete details of contents, see your July 15, 1954, issue of Metal Progress . . . which contains all the articles now being offered in this cloth-bound edition. Price is $4.00 to ASM members, $5.00 to nonmembers.

American Society for Metals
7301 Euclid Avenue, Cleveland 3, Ohio

Rush me a copy of the cloth-bound 1954 Supplement to the ASM Metals Handbook.

Name_____

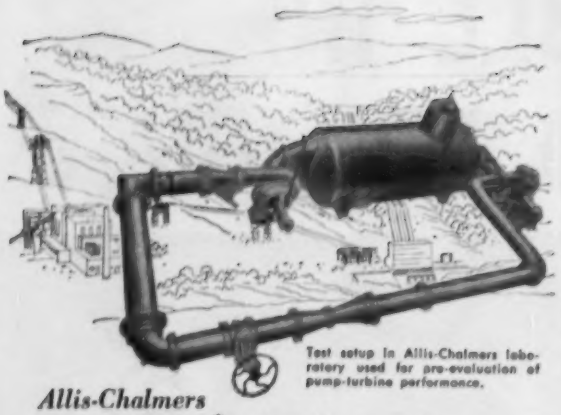
Company_____

Address_____

City_____ State_____

Member of_____ ASM Chapter

☐ $4.00 enclosed—ASM member ☐ Bill me
☐ $5.00 enclosed—non-member ☐ Bill my company



Test setup in Allis-Chalmers laboratory used for pre-evaluation of pump-turbine performance.

Allis-Chalmers uses **AMPCO* METAL** *to combat wear*

New reversible pump-turbine has Ampco metal at a critical point — to assure continuous high efficiency with minimum maintenance

Here's why Allis-Chalmers uses Ampco for wearing rings in their new reversible pump-turbine.

Ampco Metal resists *all* forms of wear—metal-to-metal, erosion, corrosion, cavitation, etc. It has high compressive strength. It has high impact and fatigue values. And it's available in most any needed form.

Put guts at critical points in both *your* product and production machinery with Ampco. Call your nearby Ampco field engineer or write us.

*Reg. U. S. Pat. Off.

AMPCO

Sole producer of genuine Ampco Metal

Ampco Metal, Inc.
Dept. MP-2, Milwaukee 46, Wisconsin
West Coast Plant • Burbank, California

B-378

Auto-accessory manufacturer eliminates rejects, cuts costs with dies of **AMPCO*** *metal*

A. S. Campbell Co., Inc. switched to Ampco, forms hub caps without work scoring or roping

Exceptionally low friction coefficient puts an end to galling, loading, scratches, die marks. You make a better product with fewer costly finishing operations. You cut scrap loss.

Little or no pickup. You get runs many times longer than with steel dies without redressing. You reduce idle time, keep your drawing or forming line at top efficiency.

Seventy sizes of die blanks in solid rounds, rectangles, and centrifugally cast rings are now available from stock at *new low prices*. Ask your nearby Ampco Field Engineer for full details or write us.

*Reg. U. S. Pat. Off.

AMPCO

Sole Producer of Genuine Ampco Metal

Ampco Metal, Inc.
Dept. MP-2 • Milwaukee 46, Wisconsin
West Coast Plant • Burbank, California

B-368

METALLURGICAL MICROSCOPES by UNITRON

UNITRON METALLOGRAPH and UNIVERSAL CAMERA Microscope, New Model U-11

- For visual observation, measurement, and photography of both opaque and transparent specimens.
- Bright field, dark field, and polarized illumination.
- Revolving nosepiece with 5 objective lenses, 4 photographic eyepieces, 3 visual eyepieces. Coated optics. Magnification range: 25-2000X.
- Compact and entirely self-contained with built-in 3¼" x 4¼" camera, high-intensity illuminator, variable transformer.
- The image is automatically in focus in the camera—transition from observation to photography is instantaneous.
- Transmitted light accessories for transparent specimens included.
- Calibrated square mechanical stage with rotatable stage plate.
- Many other important features and accessories including polarizing apparatus, filters, micrometer eyepieces, film holders, etc. Cabinet.
- 35 mm camera attachment and low power (5-40X) accessories available at extra cost.

COMPLETE UNIT only fob Boston **$1145.**

UNITRON Model MEC

is of the inverted type and designed for visual observation of metals, ores, minerals, etc. It includes many of the features of the Model U-11 Metallograph which are connected with visual observation of opaque specimens. 25-1500X.

- transformer built into microscope base.
- vertical illuminator with iris diaphragm and filters.
- coarse and fine focusing.
- large mechanical stage with graduated circular rotatable stage plate.
- calibrated polarizing apparatus.
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: P5X, Micrometer 10X, K15X.

COMPLETE only fob Boston **$319.**

UNITRON Model MMU

pioneers several new features available for the first time, as well as including features found only in instruments selling for over twice our unusually low price. For metals and other opaque specimens and also transparent specimens, under both ordinary and polarized light. An ideal, all-purpose laboratory instrument. 25-1500X.

- transformer built into microscope base.
- vertical illuminator with iris diaphragm and filters.
- illuminator mounts on stage for oblique lighting.
- illuminator mounts substage for transparent specimens.
- coarse and fine focusing.
- focusable stage.
- calibrated drawtube.
- polarizing apparatus.
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: P5X, P10X, K15X.

COMPLETE only fob Boston **$287.**

UNITRON Metallurgical Microscopes are chosen by leading firms such as Union Carbide & Carbon, Goodyear Atomic, General Motors, American Smelting and Refining, CBS-Hytron, Sperry Products, Raytheon, etc. These companies are particularly well equipped to appreciate precision workmanship, value, and quality. Why not find out more about these fine instruments?

Write for illustrated catalog on these and other UNITRON Microscopes.

UNITED SCIENTIFIC CO.

204-6 MILK ST. **Dep't. PB-2** **Boston 9, Mass.**

Revco

SUB-ZERO CHESTS

Temperatures to

-95° F

BELOW ZERO

For Shrink Fits
Seasoning Gauges
Precision Tools
Laboratory Tests

SUB-ZERO MODEL SZH-153 Shown
REVCO RIVET COOLER with 90 Rivet Canisters available

Special Equipment added to meet Your Needs, if desired.

MODEL	CU. FT.	TEMP. PULL DOWN 70° RM	CAPACITY Inside (") A	B	C	OUTSIDE Dimen. (") L	W	H	Hermetic UNITS* HP
SUB-ZERO SZH-153	1.5	−95°	23	9	12½	42	28	43	½ & ¼
SUB-ZERO SZH-653	6.5	−85°	47	15	16	60	28	43	½ & ¼
RIVET COOLER RSZ-503	5.0	−30°	30	16	18	42	28	41	¼

*Fan Cooled; Refrigerant F22 and F12; Current 110/60 • WRITE TO:

REVCO INC. . . . DEERFIELD, MICH.

KENTRALL Hardness Tester

MAKES BOTH Superficial & Regular Tests

Thoroughly proven in the field over the past two years, the KENTRALL makes all Superficial Rockwell tests (15, 30 and 45 kg. loads), as well as all Regular Rockwell tests (60, 100 and 150 kg. loads).

Want complete information? Write for Bulletin RS.

The **Torsion Balance** *Company*

Main Office and Factory: Clifton, New Jersey
Sales Offices: Chicago, San Francisco

Arwood investment casting saves up to 75%... even on complicated shapes

The Arwood investment casting process permits great design freedom. Many former sub-assembly jobs are now being designed as single-unit castings, with complicated parts being cast in unmachinable alloys. Applications are virtually unlimited.

Our engineers will be pleased to go over your parts problems with you and help cut your own costs. Why not submit parts or prints to us for quotations? Consultation is free of obligation, of course.

Write for free literature describing the investment casting process.

CASE STUDY

DESIGNATION: Female Hinge

METAL USED: Stainless Steel (AISI 302)

QUALITY CONTROL: Chemical and physical affidavits furnished. Test Bars submitted. Produced with 100% X-Ray requirements.

PARTS: Designed and cast as single unit. Formerly composed of three units welded together.

ADVANTAGES: Strengthened with re-inforcing ribs in U-Bracket. Weight decreased without decrease in strength. Reaming holes only machining required. Formerly holes countersunk outer sides only, now cast with radii on both inner and outer sides. Greatly reduced cost.

ARWOOD

PRECISION CASTING CORP.

73 WASHINGTON STREET • BROOKLYN 1, N. Y.

PLANTS: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.

WHAT IS YOUR TOUGHEST CLEANING JOB IN AIRCRAFT PRODUCTION?

Does any job in the following list give you trouble? If you'll circle the corresponding number in the coupon, we'll be glad to tell how we can help you.

This list of cleaning (and related) jobs was made up with the advice of several of our customers in aircraft production. It shows, in order of volume, the jobs on which Oakite has most frequently been able to save them time and money. Here it is:

1 Cleaning aluminum, steel and magnesium
2 Stripping paint (solvent or hot tank)
3 Machining, grinding, forming
4 Deoxidizing aluminum
5 Steam cleaning aluminum and steel
6 Deflocculating paint in spray booths
7 Preparing metal for painting
8 Removing scale and corrosion
9 Preventing corrosion

FREE Our 48-page illustrated booklet "*How to Clean Metals in Aircraft Production*" contains information on all the cleaning jobs in the list.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS • METHODS • SERVICE

Technical Service Representatives in Principal Cities of U. S. and Canada

OAKITE PRODUCTS, INC.
26H Rector St., New York 6, N. Y.

Send me a **FREE** copy of your booklet "*How to Clean Metals in Aircraft Production.*"

I especially wish to get better results in the jobs indicated by the numbers circled below:

1 2 3 4 5 6 7 8 9

NAME _____

COMPANY _____

ADDRESS _____

DILLON *Universal* TESTER

Motorized or Hand Operated

Engineering skill at its highest! COMPRESSION-TENSILE-TRANSVERSE and SHEAR testing combined in one portable instrument.

7 different gauges available—all interchangeable! Capacities from 250 up to 10,000 lbs. Dillon Universal Tester handles rounds, flats or special shapes and—for split accuracy—is calibrated with Proving Ring certified by U. S. Bureau of Standards. Has maximum hand, self-aligning grips, ball bearings. America's most popular low-priced tester! Write for illustrated brochure.

W. C. DILLON & CO., INC.
14628K KESWICK STREET
VAN NUYS (Suburb of Los Angeles)
CALIFORNIA

GRIPPING FIXTURES AVAILABLE FOR ALL ASTM OR FED. SPECS.

YOUNG BROTHERS OVENS

the most economical answer to your HEAT TREATING PROBLEMS

Batch-Type Heat Treat Oven

Young Brothers Ovens—whether standard types or special designs—are engineered for maximum savings and uniform results. For over 50 years, in hundreds of leading plants, Young Brothers Ovens have proven their outstanding efficiency and economy of operation.

Whatever your problem in heat treating . . . regardless of the process you use, there is a Young Brothers Batch or Conveyor Oven that will solve your problem. Experienced engineers are available for consultation without obligation. Write for Bulletin 14-T, today!

YOUNG BROTHERS COMPANY
1829 Columbus Road Cleveland 13, Ohio Estab. 1896

BARBER COLMAN

Impressor

for quick, on-the-spot hardness testing of non-ferrous metals and plastics

Simple to operate . . . gives an instant, dependable measure of hardness. Operates on principle of forcing a spring-loaded indenter into the surface with the amount of penetration registering on a dial indicator. Can be used in any position . . . tamperproof . . . compact . . . rugged, yet weighs only 12 oz. Thousands used by industry.

Write today for complete details.

BARBER-COLMAN COMPANY, Dept. V, 1218 Rock St., ROCKFORD, Illinois

BUZZER

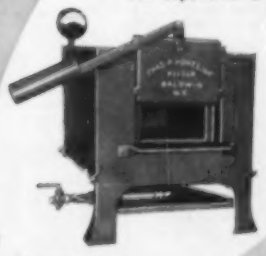
Reg. U. S. Pat. Off.

INDUSTRIAL Gas EQUIPMENT

NO BLOWER OR OTHER POWER NEEDED

JUST CONNECT TO GAS SUPPLY

BUZZER Equipment, a buy-word since 1911, provides the hottest and quickest heating . . . without blower or power. Wide range of turn down and heat control. You can depend on a BUZZER.



Oven Furnaces

Send for complete BUZZER Catalog.

CHARLES A. HONES, Inc.

126 SO. GRAND AVE., BALDWIN, L. I., N. Y.

BURNERS - FURNACES (Heat Treating, Melting, Soldering)

Mfrs. since 1911

WHAT'S NEW AT BRISTOL...

Now... Bristol thermocouples with metal-ceramic protecting tubes

Bristol's new metal-ceramic LT-1 protecting tubes are the most important advance in thermocouple technology in years.

Combining the thermal conductivity and shock resistance of metal with the corrosion and oxidation resistance of ceramic materials, the new protecting tubes will last far longer than ordinary tubes, give you closer control and faster response.

Here are the advantages of the metal-ceramic LT-1's

- Resistance to combustion gases at temperatures up to 3100°F
- Resistance to oxidation in air at temperatures up to 2200°F
- Retention of strength at high temperatures – 1800 to 2500°F
- Greatly superior to most ceramics in resistance to thermal shock
- Resistance to attack by molten metals and furnace slag
- Increased sensitivity – the ⅛ inch wall has a high thermal conductivity

Get the whole story on Bristol's new tubes. Write for Bulletin P1261 today. The Bristol Company, 106 Bristol Road, Waterbury, Conn.

4.19

BRISTOL

Points the Way in Human-Engineered Instrumentation

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Metal Progress

Taylor Lyman, *Publisher*

A. P. Ford, *Sales Manager*

George H. Loughner, *Production Manager*
7301 Euclid Ave., Cleveland 3—UTah 1-0200

District Managers
John F. Tyrrell and John B. Verrier, Jr.
55 W. 42nd St., New York 18—CHickering 4-2718
Ralph H. Cronwell
53 West Jackson Blvd., Chicago 4, Ill.—WAbash 2-7822
Don J. Billings
7301 Euclid Ave., Cleveland 3—UTah 1-0200

PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY

• Index to Advertisers •

Acheson Colloids Co. ..... Back Cover
Ajax Electrothermic Corp. 62
Aldridge Industrial Oils, Inc. 53, 60
Allegheny Ludlum Steel Corp. 37
Allied Research Products, Inc. 128
Alloy Engineering & Casting Co. 189
Almco Supersheen 56
Alpha Corp. 56
Alvey-Ferguson Co. 192
American Brass Co. 169
American Chemical Paint Co. 130
American Cyanamid Co.
Metal Chemicals Section 106C
American Gas Furnace Co. 147
American Machine & Metals, Inc. 12
American Non-Gran Bronze Co. 57
American Optical Co. 164
American Platinum Works 161
American Smelting & Refining Co. 187
American Society for Metals 184-185, 207
Ampco Metal, Inc. 208
Apothecaries Hall Co. 27
Arcos Corp. 32, 33
Armour & Co., Ammonia Div. 159
Armstrong-Blum Mfg. Co. 160
Arwood Precision Casting Corp. 209
Ashworth Brothers, Inc. 190

Babcock & Wilcox, Tubular Products Div. ... 36
Baird Associates 66
Baker & Co., Inc. 306
Baldwin-Lima-Hamilton 197
Barber-Coleman Co. 211
Bausch & Lomb Optical Co. 106D
Bethlehem Steel Co. 173, 191
Beder Scientific Co. 53
Branson Instruments, Inc. 54
Bristol Co. 211
Brooks & Perkins, Inc. 196
Buehler, Ltd. 193

Cambridge Wire Cloth Co. 138
Carborundum Co. 69, 157
Carl-Mayer Corp. 10
Carlson Co., G. O. 142
Carpenter Steel Co. 179
Cities Service Oil Co. 177
Chace Co., W. M. 178
Chase Brass & Copper Co. 163
Cincinnati Milling Machine Co. 153
Cincinnati Sub-Zero Products Co. 15
Cisco Equipment Co. 55
Clark Instrument Co. 202
Columbia Tool Steel Co. 192
Consolidated Vacuum Corp. 201
Continental Foundry & Machine Co. ..... 52A, B
Continental Industrial Engineers, Inc. 180
Cooley Electric Manufacturing Corp. 59
Crucible Steel Co. of America 4, 39, 51, 65

Dempsey Industrial Furnace Corp. 60
Detroit Electric Furnace Div.,
Kuhlman Electric Co. 204
Detroit Testing Machine Co. 53
Dillon & Co., W. C. 210
Dow Furnace Co. 132
Du-Lite Chemical Corp. 55
duPont de Nemours & Co., Inc. 64, 137
Duraloy Co. 172

Ekstrand & Tholand, Inc. 58
Electric Furnace Co. ..... Inside Back Cover
Electro Alloys Div., American Brake Shoe Co. 2
Electro Metallurgical Co., Unit of
Union Carbide & Carbon Corp. 121
Engineered Precision Casting Co. 57
Erico Products, Inc. 58
Erie Foundry Co. 72
Ethyl Corp. 129

Fahralloy Co. 195
Finkl & Sons Co., A. 21
Foxboro Co. 156B

Gardon City Fan Co. 58
Gas Machinery Co. 16
General Alloys Co. 205
General Electric Co. 143
G. E. X-Ray Co. 40
Gordon Co., Claud S. 200
Great Lakes Carbon Corp. 74

H & H Tube Co. 24
Haynes Stellite Co., Unit of
Union Carbide & Carbon Corp. 183
The Hays Corp. 61
Hevi Duty Electric Co. 166, 167
High Vacuum Equipment Corp. 206
Holcroft & Co. 36A
Hones, Inc., Chas. A. 211
The Hoover Co. 58
Houghton & Co., E. F. 11
Hydraulic Press Mfg. Co. 181

Illinois Testing Laboratories, Inc. 182
Industrial Filtration Co. 141
Industrial Heating Equipment Co. 60
International Nickel Co. 70, 108A
Ipsen Industries, Inc. 71
Ingersoll Steel Div.,
Borg-Warner Corp. 67

Jelliff Mfg. Corp. 55
Johns-Manville 168
Jones & Laughlin Steel Corp. 30

Kemp Manufacturing Co. 165
Kennametal, Inc. 170
Kinney Mfg. Div. of N. Y. Air Brake Co. ... 200
Koppers Co., Inc., Engineering
& Construction Div. 127

Lakeside Steel Improvement Co. 61
Latrobe Steel Co. 63
Lavin & Sons, Inc., R. 172B
Lebanon Steel Foundry 131
Leeds & Northrup Co. 38
Lepel High Frequency Labs 50
Lindberg Industrial Corp. 8-9
Lindberg Steel Treating Co. 60
Little Falls Alloys, Inc. 58
Lord Chemical Co. 198
Lucifer Furnaces, Inc. 60

Magnetic Analysis Corp. 54
Mahon Co., R. C. 172
Manhattan Rubber Div., Raybestos
Manhattan, Inc. 56
Marshall Products Co. 148
Maurath, Inc. 58
Merrill Bros. 194
Metal Carbides Corp. 203
Metalwash Machinery Corp. 59
Midvale Co. 49
Minneapolis-Honeywell Regulator Co.
(Industrial Division) 174-175
Mitchell Radiation Products Corp. 26
Morehouse Machine Co. 23
Murray Way Corp. 140B

National Carbon Co., Unit of
Union Carbide & Carbon Corp. 135
National Machinery Co. 44
National Metal Abrasive Co. 176
Niagara Alkali Co. 48
Niagara Blower Co. 156
Nitralloy Corp. 42
Nitrogen Division
Allied Chemical & Dye Corp. 188
North American Mfg. Co. 75
Northwest Chemical Co. 45
Norton Co. 22

Oakite Products, Inc. 210
Ohio Crankshaft Co. 139
Ohio Seamless Tube Div. 28

Pangborn Corp. 73, 196
Pereny Equipment Co. 27
Pittsburgh Lectrodryer Corp. 46
Plume & Atwood Mfg. Co. 186
Pressed Steel Co. 125
Production Specialties, Inc. 54, 56

Raybestos-Manhattan, Inc.,
Manhattan Rubber Div. 56
Revco, Inc. 209
Revere Copper & Brass, Inc. 123
Rigidized Metals Corp. 57
Rockwell Co., W. S. 202
Rolock, Inc. 144
Roll Formed Products Co. 57
R-S Furnace Corp. 162
Rubicon Co. 204
Ryerson & Son, Inc., Jos. T. 76

Salem-Brosius, Inc. 172A
Sandvik Steel, Inc. 143
Sessions & Son, J. H. 57
Sinclair Refining Co. 151
Solventol Chemical Products, Inc. 3
Somers Brass Co., Inc. 194
Spencer Turbine Co. 149
Standard Steel Treating Co. 56
Stanwood Corp. 59
Star Stainless Screw Co. 57
Steel City Testing Machines, Inc. 134
Struthers Wells Corp. 126
Sun Oil Co. 14
Superior Steel Corp. 140A
Superior Tube Co. 199
Surface Combustion Corp. ..... Inside Front Cover
Swift Industrial Chemical Co. 54
Sylvania Electric Products, Inc. 158

Taber Instrument Co. 54
Technic, Inc. 54, 56
Thermo Electric Co., Inc. 146
Timken Roller Bearing Co. 34
Titan Metal Mfg. Co. 156A
Torsion Balance Co. 53, 209

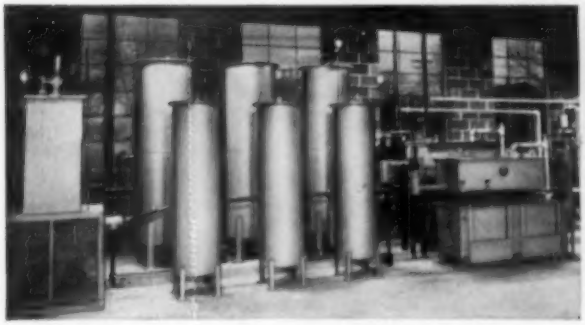
Uddeholm Co. of America 133
Union Carbide & Carbon Corp. 121, 135, 183
Unitcast Corp. 136
United Scientific Co. 208
United States Steel Corp. 17-18-19-20
United Wire & Supply Corp. 198
Upton Electric Furnace Co. 61

Vacuum Metals, Inc. 52
Vanadium Corp. 47
Van Der Horst Corp. 152

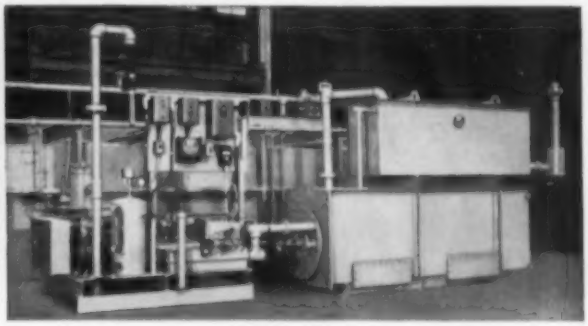
Watson-Stillman Company Div.
of H. K. Porter Company, Inc. 41
Wauker Engineering Co. 190
Westinghouse Electric Corp. 6-7, 134, 154-155
Wheelco Instruments Div. 36B
Wheelock, Lovejoy & Co., Inc. 150
White Metal Rolling & Stamping Corp. 57
Wilson Mechanical Instruments Div.,
American Chain & Cable 140
Wiretex Mfg. Co. 59

Yoder Co. 43
Young Bros. 210
Youngstown Sheet & Tube Co. 68
Youngstown Welding & Engineering Co. 55

KABLE PRINTING CO.



An EF installation consisting of a 1500 and a 3000 cfh exothermic horizontal water cooled type special atmosphere unit, each with desulphurizing towers and refrigerators for bright annealing steel and copper, and clean annealing brass.



An EF kerosene exothermic gas generator. These are also built in several sizes and types for producing special atmospheres for use in bright annealing copper and steel products in areas where fuel gases are not available.

EF SPECIAL ATMOSPHERE EQUIPMENT

For any Heat Treating Process . . . any Capacity

Long Experience = High Efficiency + Low Maintenance

Gas scrubbing units are available in several sizes and types for use with EF special atmosphere generating equipment where it may be necessary to remove CO_2 or H_2S.

● As pioneers in the development and use of equipment for producing low cost special atmospheres, we are in position to furnish a wide range of reliable, thoroughly tested special atmosphere units, including endothermic and exothermic gas generators, ammonia dissociators, refrigerators, dryers, desulphurizers, gas scrubbing units and other special atmosphere equipment — equipment with a reputation for high efficiency,— and low maintenance and operating costs.

Submit your furnace or special atmosphere problems to experienced engineers — *IT PAYS*

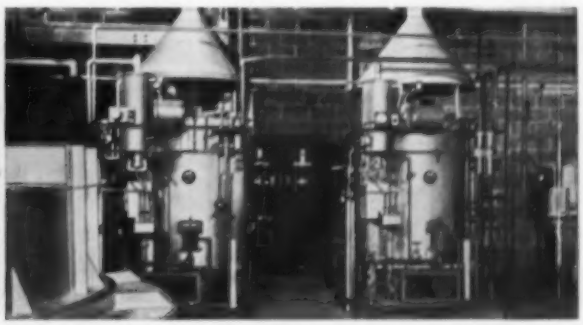
EF Ammonia Dissociators are built in many sizes and types for producing highly reducing atmospheres as required for bright annealing stainless; and other annealing and normalizing processes and preventing decarburization.

THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R.R. *Salem - Ohio*

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

EF special atmosphere installation consisting of an exothermic generator, refrigerator and dryer as used with EF furnaces for bright and clean annealing ferrous and non-ferrous products.



An installation consisting of two small EF oil fired endothermic generators producing special atmospheres from propane for carburizing and other processes.

telling the story of 'dag' dispersions

How You Can Solve Hot-Lubrication Problems

Investigate the unique values of a 'dag' Colloidal Graphite *dry-film lubricant.*

'dag' dispersions are available in a choice of liquid carriers: oils, water, volatile hydrocarbons, and resin-solvent combinations. You'll find that the dry lubricating films produced by these dispersions are heat-resistant . . . much more enduring than conventional petroleum lubricants. And they keep work pieces well lubricated at all your metalworking temperatures.

Tell us your problems or write *today* for Bulletin No. 426-B7.

Dispersions of molybdenum disulfide are available in various carriers.

We are also equipped to do custom dispersing of solids in a wide variety of vehicles.

dag DISPERSIONS

Acheson Colloids Company, Port Huron, Mich.

. . . also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND

try dag resin bonded dry films for permanent lubrication